MARCH 25 Cents

THE TECH ENGINEERING NEWS

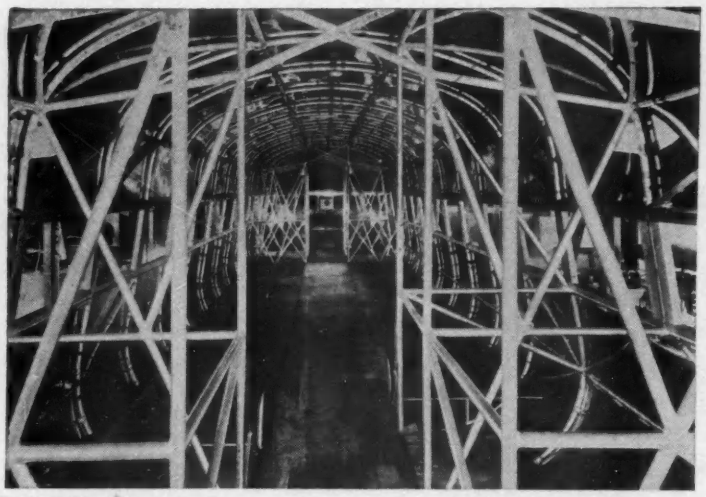
IN THIS ISSUE

Blast Furnaces

Geology In the Far East

Opportunities For Civil Engineers

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



HERE'S HOW—the framework of the light weight, streamlined rail cars for high speed is Lindewelded from chrome-molybdenum steel tubing.

Mastery over all Metals

Welding Makes Jointless Structures Possible in Practically All Commercial Metals and Alloys

By A. B. KINZEL*

One great advantage of using welding is that practically every commercially available metal and alloy can be made by this means into a jointless assembly.

Contributes to Home Comforts

Numerous articles fabricated by welding are found in most homes. Familiar ones cover a wide range of metals—kitchen ware and furniture of aluminum, copper and stainless steel; copper tubing in refrigerators, sheet metal in refrigerator boxes; kitchen cabinets and gas ranges; water pipes of copper, brass, iron and steel; furnaces and hot water tanks of strong heat-resisting irons and steels. Even the tiny alloy wire elements in radio tubes are welded.

Simplifies Automobile Maintenance

Automobile manufacturers use welding for innumerable assemblies where your safety and comfort depend on permanent strength and tightness. The modern automobile repair man also uses welding. With welding he quickly restores broken parts to use again. Steel bumpers, fenders, frames are readily made jointless by welding—as strong as or stronger than the original piece. Cracked cylinder blocks and broken aluminum crank cases are welded. Valves and valve seats are made service free by welding a thin coating of Haynes Stellite to the wearing surfaces to give longer life and added thousands of low cost miles.

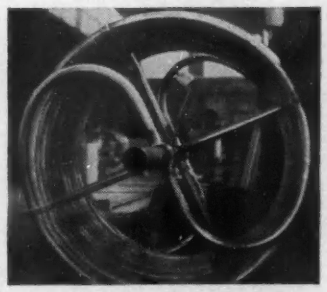
Aids Industrial Users

In industry—for tanks, containers, piping and a wide variety of other machinery and equipment of all sizes, shapes and metals—the use of welding is even more extensive.

Welding Marches Ahead

The wide-spread use of welding for various metals and alloys has been due largely to constant advances in technique and materials. Typical among these is the development of Lindewelding, a procedure for the rapid welding of steel pipe and plate. Speed increases of 50 to 65 per cent and material savings of 25 to 50 per cent over previous methods have been made.

Bronze-welding, welding with a bronze welding rod, is widely used for both repair and production. Smooth joining of metals or alloys of different compositions can be accomplished by bronze-welding. Steel can be bronze-welded to cast iron, bronze and copper can be joined, brass and steel plate can be united.



EVERY METAL—responds to the oxy-acetylene blowpipe. This stainless steel coil for cooling milk has welded joints.

Makes Modern Metal Designs Jointless

Exact procedures for the welding of corrosion-resistant steels and alloys have been developed. Welds so made are sound, strong and ductile. Resistance of the welded joint to corrosion makes it valuable also for use in joining special alloys such as Monel Metal and Everdur. Welded aluminum alloy chairs, tables and other furniture have been made possible through the development of special aluminum welding rods.

At Your Command

Modern welding technique, plus the great variety of metals and alloys on the market today provide many new possibilities for your products. Information and data which will help you use welding to wider advantage may be had from the nearest Sales Office of The Linde Air Products Company, a unit of Union Carbide and Carbon Corporation. These are located at Atlanta—Baltimore, Birmingham, Boston, Buffalo, Butte—Chicago, Cleveland—Dallas, Denver, Detroit—El Paso—Houston—Indianapolis—Kansas City—Los Angeles—Memphis, Milwaukee, Minneapolis—New Orleans, New York—Philadelphia, Phoenix, Pittsburgh, Portland, Ore.—St. Louis, Salt Lake City, San Francisco, Seattle, Spokane and Tulsa.

WELDING ALUMINUM—an architectural plaque, modern in design, is repaired by a modern method.

Everything for oxy-acetylene welding and cutting—including Linde Oxygen, Prest-O-Lite Acetylene, Union Carbide and Oxweld Apparatus and Supplies—is available from Linde through producing plants and warehouse stocks in all industrial centers.

*Chief Metallurgist, Union Carbide and Carbon Research Laboratories, Inc., Unit of Union Carbide and Carbon Corporation.

OUR AUTHORS

RALPH HAYES SWEETSER, '92, is the author of the article on *Blast Furnaces*. Mr. Sweetser has written for *The Tech Engineering News* before, contributing the article *Obsolescence in the Iron Industry* to the February 1931 issue. He assisted Professor R. H. Richards of the Institute in the preparation of the first book on ore dressing written in English and considered by many to be one of the best books ever written on that subject. In 1905, while working for the Algoma Steel Co., he operated the largest charcoal blast furnace and made a world's record for tonnage production with a charcoal blast furnace. Upon his instigation a publicity campaign was started in 1922 to force coal dealers to stop selling high ash coal. Through his efforts a poster campaign was pushed forward and the miners were made "clean coal" conscious. In 1927 Mr. Sweetser wrote a book *Clean Coal* and in 1929 he brought out *Modern Blast Furnace Theory and Practice*.

GEORGE TILLEY SEABURY, '02, who wrote the article on *Civil Engineers*, is the Secretary of the American Society of Civil Engineers. For four years after his graduation he was a field engineer for various contractors and a construction engineer on Grand Central Terminal, Riverside Drive, and the New York subways. During the next nine years he was with the Board of Water Supply of New York City employed as an engineer on the construction of the Catskill Aqueduct. His next post was that of District Engineer in charge of the preliminary surveys and design of the water supply system of Providence, R. I. During the war he held the rank of Major, Construction Division, Quartermaster Corps, and was the Supervising Engineer in charge of construction on the Atlantic Seaboard. After the war he organized Geo. T. Seabury, Inc., a general contracting firm specializing in heavy construction.

GORDON ARTHUR POPE, a member of the class of 1939, is the writer of the article *Uniting the 'Frisco Bay Area*. He did a great deal of research in the material published on these bridges and has found some remarkable figures. Mr. Pope, who comes from Riverside, Connecticut, is a member of the boxing team.

FREDERICK G. CLAPP, '01, is the author of *A Study of Geology in Asia*. The authoritativeness of this article cannot be questioned because the author has explored most of the territory on which he writes. For two years after his graduation, Mr. Clapp was an instructor at the Institute, then he was employed as a geologist by the United States Geological Survey. In 1908 he became a consulting geologist and petroleum engineer and in this capacity has explored most of the oil and mineral lands of the East. Mr. Clapp has twice held the important post of Petroleum Adviser to the Imperial Government of Iran. He is a member of the Explorers' Club of New York, a fellow of the American Association for the Advancement of Science, and belongs to many learned societies.

we show **M. I. T.**
- a real **Bargain**

JAYSON SHIRTS

now $1.55 2 for $3.00
Regularly $1.95

These shirts have the no-wilt, no-starch collar attached. They are not seconds but regular stock being cleared to make room for a new lot arriving at once.

THE TECH COOP

76 Massachusetts Avenue Cambridge, Massachusetts

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS

The MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses in Engineering and Science, each of four years' duration, leading to the degree of Bachelor of Science in:

AERONAUTICAL ENGINEERING
ARCHITECTURAL ENGINEERING
BIOLOGY AND PUBLIC HEALTH
BUILDING CONSTRUCTION
CHEMICAL ENGINEERING
CHEMICAL ENGINEERING PRACTICE
CHEMISTRY
CIVIL ENGINEERING
ELECTRICAL ENGINEERING
ELECTROCHEMICAL ENGINEERING
ENGINEERING ADMINISTRATION
GENERAL SCIENCE
GENERAL ENGINEERING
GEOLOGY
INDUSTRIAL BIOLOGY
MATHEMATICS
MECHANICAL ENGINEERING
METULLARGY
MILITARY ENGINEERING
MINING ENGINEERING
NAVAL ARCHITECTURE AND MARINE ENGINEERING
PHYSICS
SANITARY ENGINEERING

The Course in Architecture is of five years' duration, and leads to the degree of Bachelor in Architecture. Five-Year Cooperative Courses in Electrical Engineering and Railroad Operation leading to the degrees of Bachelor of Science and Master of Science are also offered.

Graduate Courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are offered. The Courses leading to the degree of Master of Science include Cooperative Courses in Chemical Engineering Practice and Fuel and Gas Engineering.

The better high schools and other preparatory schools in the United States offer adequate preparation for the required entrance examinations given by the College Entrance Examination Board in June, or by the Institute in September.

Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

The Summer Session extending from June to September includes most of the subjects given during the academic year and in addition special courses for teachers.

Any of the following publications will be sent free upon request:

CATALOGUE FOR THE ACADEMIC YEAR
(WHICH INCLUDES THE ADMISSION REQUIREMENTS)
SUMMER SESSION CATALOGUE
GRADUATE STUDY AND RESEARCH

Correspondence should be addressed to the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE TECH ENGINEERING NEWS

MARCH, 1936
VOLUME XVII
NUMBER 1

CONTENTS

THE COVER: THE GREAT WALL
Courtesy—*Geographical Review*

FRONTISPIECE: IRON REFINING
Courtesy—*American Institute of Mining and Metallurgical Engineers*

BLAST FURNACE - - - - - - - - 5
By Ralph H. Sweetser

"FRISCO" BRIDGE - - - - - - - 9
By Gordon A. Pope, '39

GEOLOGY - - - - - - - - - 11
By Frederick G. Clapp

CIVIL ENGINEER - - - - - - - - 14
By George T. Seabury

EDITORIALS - - - - - - - - - 16

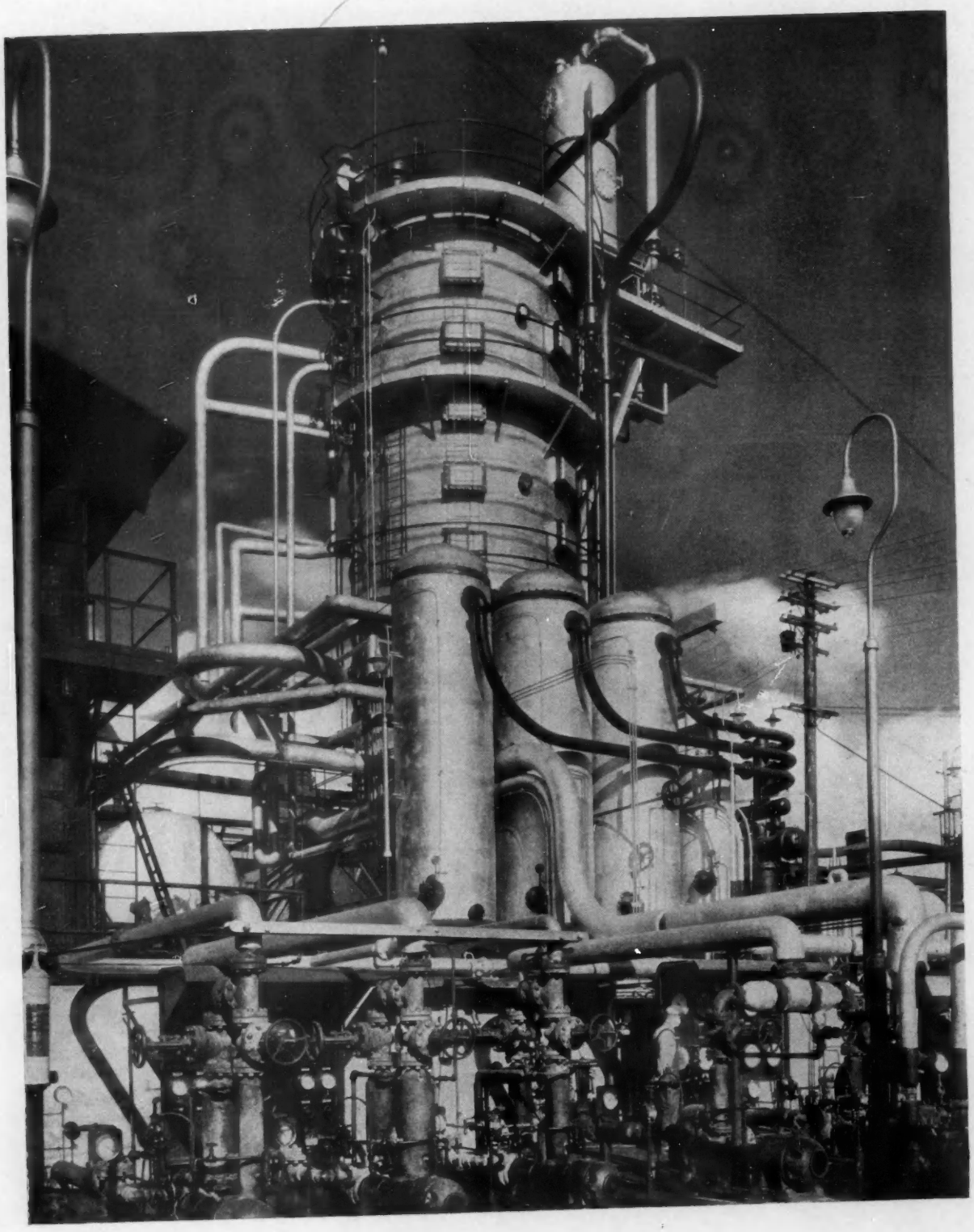
ENGINEERING DIGEST - - - - - - - 18

RESEARCH AND REVIEW - - - - - - 20

Published monthly throughout the school year, at Walker Memorial, Cambridge A, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates. Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879. Acceptance for mailing at special rates of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920. Copyright 1936 by The Tech Engineering News. Subscription per year $1.50. Foreign $1.75. Single copies 25 cents.

H. ARTHUR ZIMMERMAN
General Manager
JERVIS C. WEBB
Editor-in-Chief
FRANCIS S. BUFFINGTON
Business Manager

Technique



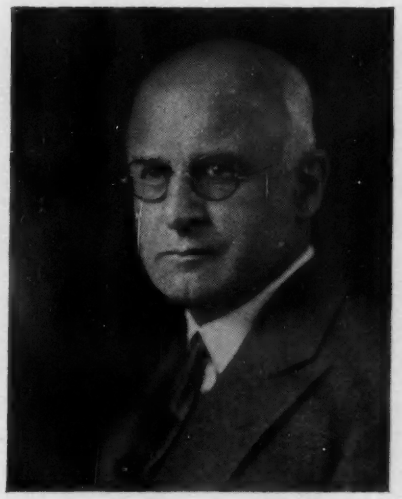
IRON REFINING

The Iron BLAST FURNACE *In Industry*

By RALPH H. SWEETSER
Consulting Metallurgical Engineer

"PIG iron is the metallic product of an iron blast furnace." That is the definition officially announced by the Canadian Government about 30 years ago when there was a bonus on every ton of pig iron made in the province of Ontario. At first the iron made was all in pigs, but when molten iron was taken in ladles from the blast furnace over to the Bessemer department the Government inspector would not certify the weights because he claimed that the molten iron was not "pig iron"; hence the legal definition.

The United States Government, in the Tariff Commission makes a very clear distinction between "iron in pigs", and states that "molten iron is not an article of commerce," and says further that, "Pig Iron" applies to all iron produced in the iron blast furnace whether used in the molten condition or cast into pigs (U. S. Tariff Commission Report on Iron in Pigs, Feb. 2, 1927).



A. I. M. E.

Pig iron is the raw material for practically all iron and steel products. It has been made in this country for nearly three centuries, and for the first one hundred years Massachusetts produced more pig iron than any other colony. Then for two hundred years Pennsylvania led all other colonies and states up to 1932 and 1933 when Ohio produced a few tons more; last year Pennsylvania took the lead again.

The first blast furnace built in Massachusetts on the Saugus River near Lynn nearly 300 years ago used charcoal for fuel in the smelting of the lean "bog" iron ores. It was a very small furnace making less than one ton of pig iron in 24 hours. The last blast furnace built in Pennsylvania uses byproduct coke for fuel in the smelting of Lake Superior iron transported hundreds of miles on railroads and on ore boats on the Great Lakes. It is a very large furnace making twelve hundred tons in 24 hours.

The blast furnace process in both these cases is practically the same; a column of solid iron ores (oxides of iron) fuel and flux descends through the vertical shaft of the blast furnace, meeting a large volume of ascending hot gases containing about 34 percent CO gas (carbon monoxide). The iron ores are reduced to metallic iron, which melts and is drawn off at intervals from the hearth of the furnace through the iron notch. The earthy constituents of the iron ores (the non-metallic elements) and of the ash in the coke combine with the lime and magnesia of the flux to form the blast furnace slag which passes out of the furnace through the cinder notch at intervals between the casts, and also at the casting time through the iron notch together with the molten iron.

The modern iron blast furnace of the year 1935 is practically the same as the composite type of a 1000-ton furnace selected by the Blast Furnace and Coke Oven Association of Chicago in 1930 with the exception that the top diameter is enlarged. It is the wonderful result of the development, through mechanical skill and "cut and try" methods in devising, of an apparatus strong enough to withstand the strain of a slowly moving descending column of solid materials gradually getting hotter and hotter till all are liquified or gasified, meeting a voluminous column of swiftly ascending hot gases gradually getting cooler. The liquefied products, the molten iron and the molten slag pass out of the furnace at the bottom intermittently, and the gasified products pass out at the top continuously.

A vertical cross-section of such a blast furnace is shown in Figure 1, which is taken from the article, "Recent Trends in Blast-Furnace Operation and Design", by B. J. Harlan in Transactions, A.I.M.E., vol. 15, 1934, and also from the paper of A. J. Boynton and S. P. McKinney, "Notes on the Development of the Iron Blast Furnace", New York meeting A.I.M.E., February, 1935. The main parts of the iron blast furnace are the hearth or crucible, the bosh, the shaft, and the top; the usual dimensions given to designate the size of a furnace are; the height inside the lining from level of iron notch to level of the top platform; the diameter of the bosh; the diameter of the hearth; the diameter of the stock line. The bosh angle is important, and is now usually 80° to 81° plus. Each part of the furnace has gradually been strengthened until now there is ample protection to the firebrick lining by means of strong steel hearth jackets, tuyere jackets, bosh bands and shells to hold the refractories in place, and water-cooled bronze bosh plates and water cooled iron hearth plates to keep the refractories from melting out too fast.

The mechanical side of the blast furnace process has been brought to a high degree of efficiency, and the principles of heat exchange between the descending solids and ascending gases are correct in theory though in most cases unevenly carried out in actual practice, but the chemical reactions are not yet satisfactorily solved because of the lack of enough research work to find out what really goes on inside the iron blast furnace, while it is in normal operation.

The Hearth

The hearth, or crucible, of the furnace is the lowest part of the interior; it is the receptacle for the molten iron after it has melted and trickled down through the bath of molten hot slag which floats on the surface of the liquid iron. This bath of slag gradually rises until its upper surface is just below the level of the bottom of the tuyeres, when the slag is drawn off through the cinder notch down to a point where the blast begins to blow out a little with the flowing slag.

The level of the center of the cinder notch is 2½ ft. to 3½ ft. below the level of the center-line of the tuyeres, depending on the size of the furnace, and is 4½ ft. to 5½ ft. above the level of the iron notch. The level of the iron notch when the furnace lining is new is usually about 18 inches above the inside bottom of the hearth but after a while the firebrick bottom gradually cuts out and there is considerable depth of molten iron in the pool that remains in the furnace even after each cast.

The iron notch may seem to be a simple and an insignificant part of the blast furnace but its proper care and upkeep is most important; through it, at intervals of three to six hours depending on the practice and the requirements for hot-metal, there will flow 50 to 200 tons of white hot molten iron at a temperature of 2550°F. to 2750° F. When the level of the iron inside the furnace is down to the point when the blast begins to blow out the hot gases, the iron notch is shut by forcing a cylinder full of "iron-notch clay" from a powerful "mud-gun", which is truly an automatic breech loader operated by steam, compressed air, or electricity. The largest and latest types allow the iron notch to be shut without taking the blast off the furnace.

The Tuyeres

Above the hearth are the tuyeres, regularly spaced around the circumference of the tuyere jacket, through which the hot blast is blown into the furnace. They are eight to sixteen in number and are made of copper, or copper bronze, water cooled. They are easily removable and are fitted tightly into a tuyere cooler which helps to protect the firebrick lining at this very hot part of the furnace. The nose of the tuyere is usually circular, although tuyeres with oval openings have been used.

The Bosh

Just above the tuyere jacket the lining of the furnace slopes outwardly till the maximum diameter of the interior of the furnace, called the bosh diameter is reached at a level about ten or eleven feet above the centerline of the tuyeres. This section of the furnace is a truncated cone with its larger diameter at the top. In most furnaces there is a cylindrical part of the furnace, four to ten feet in height, of the same diameter as the bosh diameter, called the straight part of the shaft.

The Shaft

Above the bosh comes the shaft of the furnace which is another truncated cone this time with its larger diameter same as the bosh diameter, at the bottom, and its smaller diameter near the top of the inside of the furnace.

The Furnace Top

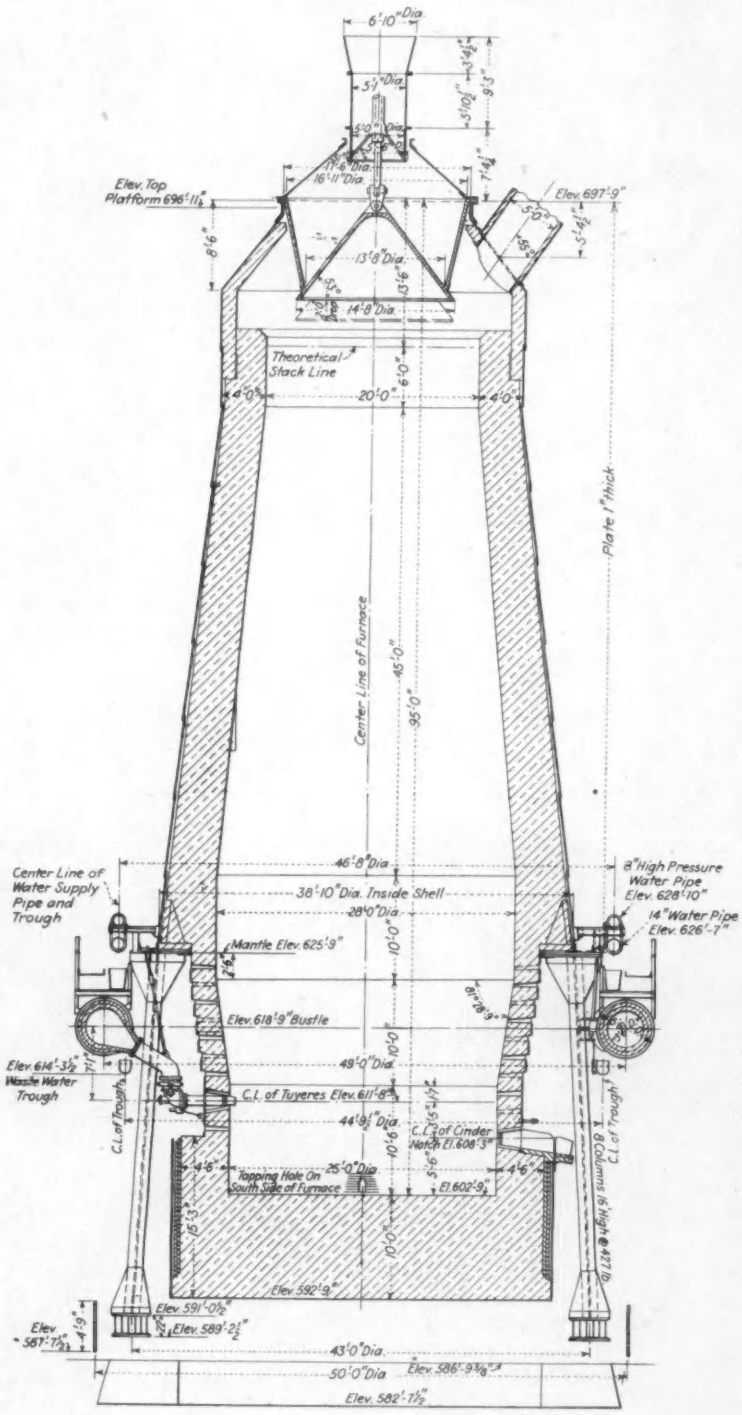
All the solid materials used in making pig iron,—the iron ore, the fuel and the flux,—are fed into the top of the furnace at more or less regular intervals and are delivered to the inside of the furnace without any serious interruption to the enormous and continuous stream of blast furnace gas that passes off the column of solid stock at the point where the cold fresh stock is delivered. The mechanical device that closes the top of the furnace so as to prevent the escape of the tons of hot gases from escaping into the air, and allows the raw materials to be delivered inside is the double bell and hopper shown at the top of Figure 1; the little bell is 5′–6″ diameter and the big bell is 14′–8″ diameter.

In order to deliver the "stock" (the mixture of the coke ore and flux) evenly around the circumference of the top of the stock inside the furnace a revolving top called the McKee top (invented by Arthur G. McKee) is almost universally used. By means of suitable mechanism the little hopper and little bell together with whatever stock is on the bell, are revolved through the predetermined degrees of a circle, and then the stock is dropped onto the big bell until the big hopper is filled with its layers of ore, fuel, and flux. The little bell is then closed and the big bell lowered so that all the stock slides down into the furnace. The level of the top of the stock inside the furnace is kept at a few feet below the level of the big bell when closed; this level is called the "stockline". When the stock in the furnace is up to this level the furnace is called "full".

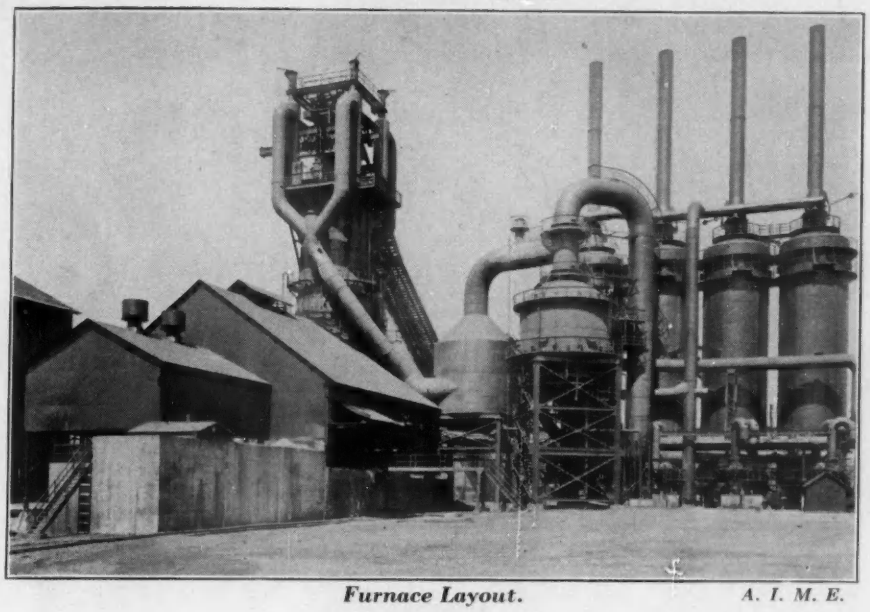
The Downcomers

The large annular space at the top of the furnace, around the big bell and hopper is filled with the hot waste gas, called blast furnace gas, which then passes out and down through two or more downcomers into the dustcatcher and through whatever cleaning devices there may be for removing the particles of fine dust from the gas. The "off-takes" for the gas are placed at equidistant points around the furnace top as shown in the picture of No. 2 furnace of the Republic Steel Corporation.

A. I. M. E.



Large furnace with stock line 20 feet in diameter.



Furnace Layout. *A. I. M. E.*

The weight of the waste gases passing off through the downcomers is at least 1½ to 1¾ times as great as the total weight of all the solid materials going into the furnace, and 3½ times greater than the combined weight of the molten iron and molten slag flowing from the furnace at the bottom. The volume of these gases is so great that the velocity at certain parts of the stream at the stock line level has been found in some blast furnaces to be greater, than the speed of Sir Malcolm Campbell's 2500 H.P. racing auto, "Bluebird" when he broke the world's record last September by driving at the rate of 301.3 miles per hour, which equals 5.02 miles per minute, or 4419 feet per second.

The Waste Gas

The temperature of the waste gas as it comes off the top of the furnace is about 250° F. to 450° F., and consequently carries off much sensible heat. Its calorific value varies from about 90 Btu to 105 Btu, according to the materials used and the blast furnace practice. Blast furnace gas is a valuable byproduct, and when properly cleaned is cleaner than the air we breathe; it is used for heating the blast for the blast furnace plant and often for surplus power, for gas engines, for underfiring coke ovens, and for various uses around the steel plant and sintering plant.

Hot Blast Stoves

About 20 percent of the waste gas is burned in the hot blast stoves for heating the blast to a temperature of 1250° F. to 1600° F., thus recovering a considerable amount of heat removed from the furnaces by the waste gases. The checker brick of the stoves absorb the heat from the burning of the waste gas in the combustion chamber of the stove; then when the cold air blast from the blowing engines is blown through the checker brick in the stoves it takes on much of the heat that has been stored up.

Blowing Engines

The air-blast is greater by weight than all the solid materials put together for the production of a ton of pig iron, being over 4 tons (8960#) per 2240# of iron. All this air is taken from the atmosphere and pumped by reciprocating engines or else rotary compressors, and forced through the hot blast stoves on into the blast furnace. This takes much power which is generated from the waste gases, either directly or indirectly so that a large part of the energy in the surplus fuel used in the blast furnace process is recovered and utilized in the process itself. Formerly all this surplus energy was consumed in heating the blast and in raising steam to furnish power for operating the whole blast furnace plant.

The Raw Materials

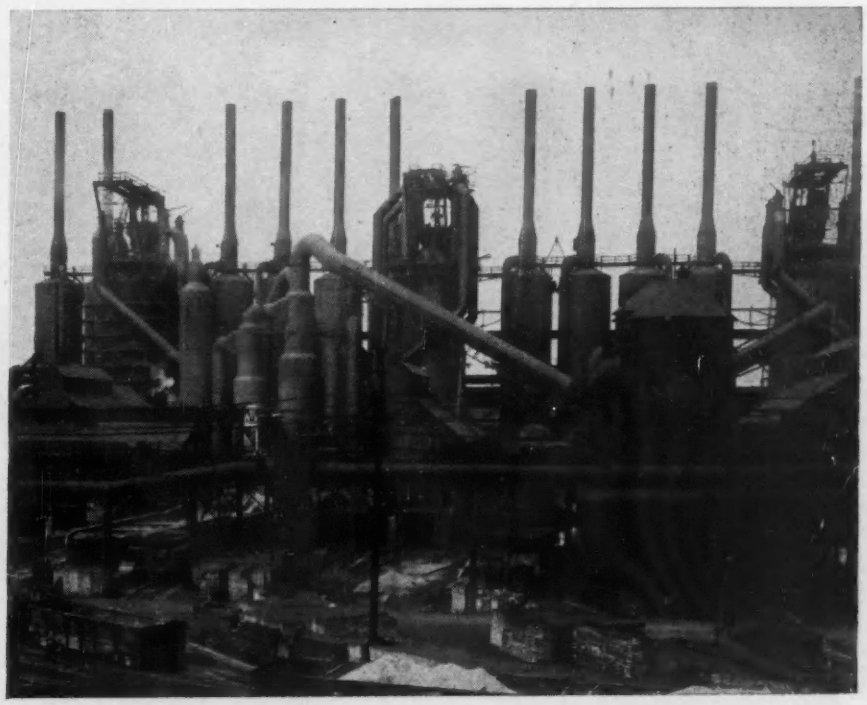
The whole iron and steel industry is based on units of iron and units of fuel (usually carbon). The element Fe, iron, makes up about 94% of the product, pig iron, the balance being other metals and metalloids. The carbon not only furnishes the heat and forms the reducing agent for smelting the iron from its ores, but a certain percentage (3.50–4.50%) of carbon enters into the chemical and physical composition of the pig iron itself.

In a typical case it required the following materials to make a ton of pig iron.

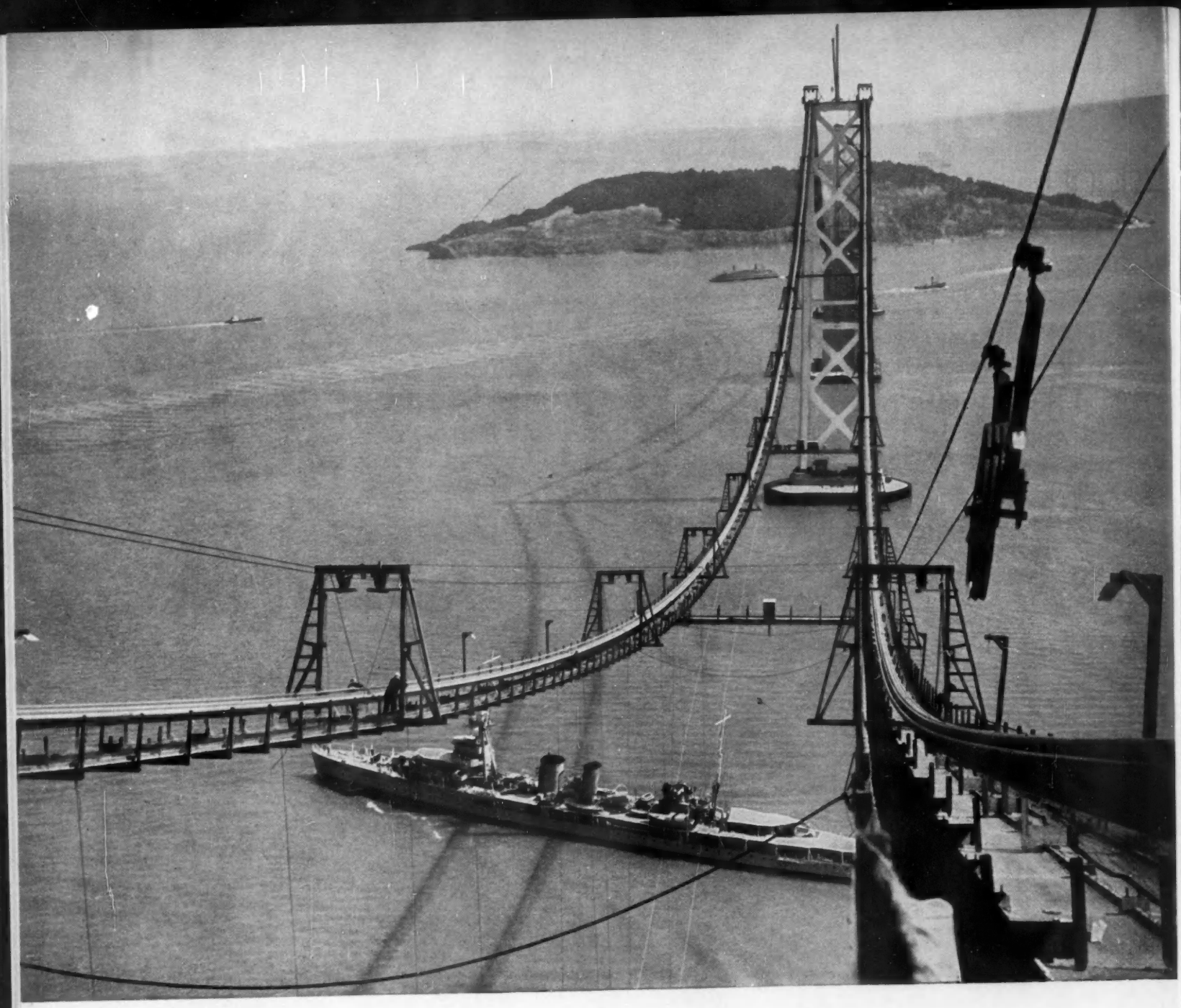
4333# =	1.934 tons	Iron Ore	(Gross tons)
2162# =	.965 "	Coke	(Gross tons)
1078# =	0.481 "	Limestone (flux)	(Gross tons)
=			
7573# =	3.380 "	Solid Materials	(Gross tons)
8885# =	3.966 "	Air-blast	(Gross tons)
16,458# =	7.346 "	Total Materials	(Gross tons)

This statement shows the importance of the blast furnace in reference to freight tonnage; to produce 1 gross ton of pig

(*Continued on page 24*)



Modern steel plant.



STRINGING CABLES ON S. F.—OAKLAND BRIDGE

Uniting the "FRISCO" *Bay Area*

By GORDON A. POPE, '39
Massachusetts Institute of Technology

THE San Francisco-Oakland Bay bridge project along with that of the Golden Gate bridge isprobably one of the greatest steps in the advancement of bridge construction that has ever been undertaken. They will be a result of a great problem which confronted the local traffic commission; that of finding a solution to the State and traffic needs of San Francisco, and of reconciling these needs with those of national defense and navagation.

Both the San Francisco-Oakland Bay and the Golden Gate bridges are by far the largest and finest bridges of their type known to the world of engineering.

The final choice for the location of the San Francisco-Oakland Bay bridge was narrowed down to a route from Rincon Hill in San Francisco over the West Channel to Oakland. This location was found to be practical from an engineering standpoint and economically feasible under a proper fiscal plan. This route would also serve the needs of transbay travel.

The total length of this bridge from the San Francisco Terminal to the Oakland Terminal approaches 43,000 feet, approximately eight and one-third miles. Over 12,000 feet of water is spanned by this immense structure.

The bridge will require approximately 200,000 tons of structural, reinforcing, and cable steel; 200,000 gallons of paint; 1,300,000 barrels of cement; and 30,000,000 board feet of lumber.

Construction commenced on July 9, 1933. The present plans indicate that the project will be completed early in January, 1937.

Plans for the Golden Gate bridge call for one whose total length from bridge head to bridge head is 6,400 feet, but whose length from portal to portal is 8,940 feet. The location of the course of this bridge runs slightly northwest from Fort Point, on the San Francisco shore, to Lime Point, on the Marin County shore.

The total distance, shore to shore, along the center line of the bridge, is 5,537 feet. The distance from the Marin shore to North Pier is 52 feet, and from the San Francisco shore to South Pier is 1,105 feet. The main span, center to center of piers, is 4,200 feet—the longest span ever to be undertaken. The maximum depth of the water through the Golden Gate is 378 feet at the center of the channel.

Suspension bridges are used in both the San Francisco-Oakland Bay and the Golden Gate structures. The Golden Gate bridge has one suspension, the largest in the world. Clearance height is 210 feet at the piers, increasing to 220 feet at the center, measured from mean high water and under maximum deflection. The elevation of the bridge floors at the piers is 242 feet 11 inches above mean high water.

The most prominent features of the Golden Gate bridge are its two great steel towers carrying the cables which support the structure. These towers are 746 feet above mean high water—the highest and largest bridge towers in the world.

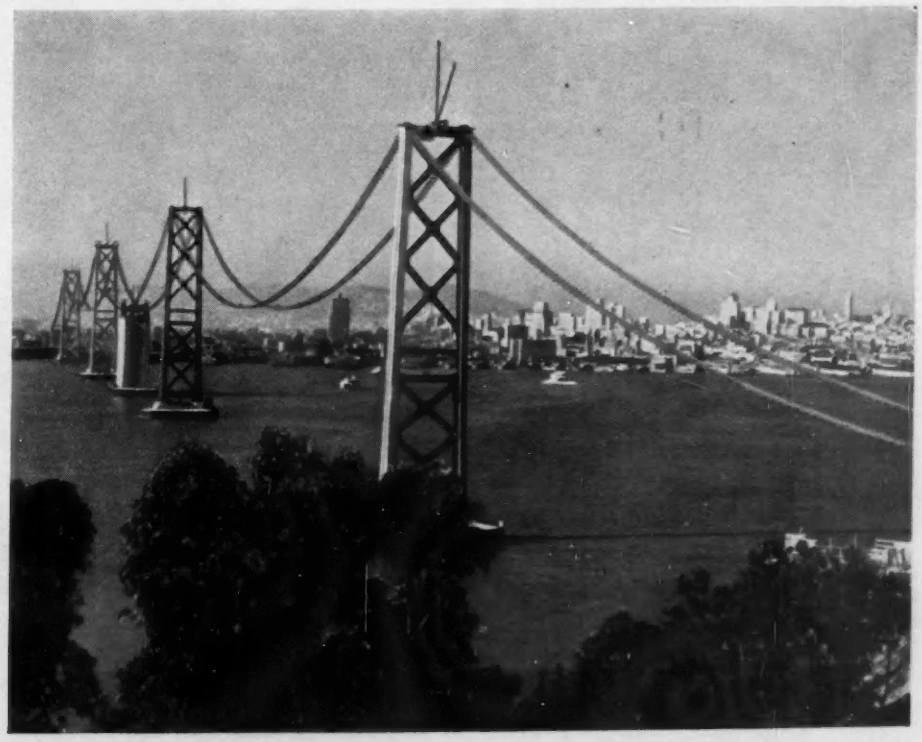
There are two cables on the Golden Gate bridge, resting on cast steel saddles at the tops of the towers and anchored on shore. Each cable is 7,660 feet long and 36 and one-half inches in diameter and contains 27,572 steel wires of 0.196 inches in diameter, laid parallel to each other and strung from anchor to anchor in one continuous operation. These wires are wrapped with galvanized steel wire and compacted by means of a special device for that purpose. Each cable weighs 11,000 tons.

Distance from center to center between the cables is 90 feet. A 60-ton roadway for six lanes of traffic and two ten-foot walks are provided.

This suspension bridge is the greatest feat in this type of bridge building that has ever been undertaken. Over 105,000 tons of structural steel has been used in this single suspension. Present figures indicate that this bridge will be completed about the same time as the San Francisco-Oakland Bay bridge.

The San Francisco-Oakland Bay bridge has two complete suspension bridges spanning the West channel, with its central anchorage approximately in the center of the channel. Suspension bridges such as these were the only practical type

Illustrations courtesy General Electric Review



A view of the double suspension span.

that would be at all feasible for a bridge covering such a large distance at the required height. Each of the suspension bridges consists of two towers, two anchorages, a stiffening truss, a floor system, and two cables with the appropriate number of suspenders. As the configuration of the earth would not allow the cables to be fastened directly to the ground, the cables are passed over piers and from there to an anchorage which lies a few hundred feet to the rear. The cables are of course equal in slope, since it is essential to have the same distribution of weight.

The great merit of the suspension bridge is in its cheapness, arising from the fact that comparatively small quantities of materials are required to carry a given load across a given span. One disadvantage to this type of bridge is in the poor distribution of the load, causing a very sensible deformation of the structure, and the suspenders must adapt themselves to the new position. This drawback is overcome to a great extent by the use of the stiffening truss. The cables are attached to the stiffening truss which is attached to the roadway, causing a much greater distribution than in the case of direct contact. Each suspension of the San Francisco-Oakland Bay bridge is 2,310 feet in length with side span of 1,160 feet on either side. Vertical clearance of the central span is from 200 to 218 feet above low water.

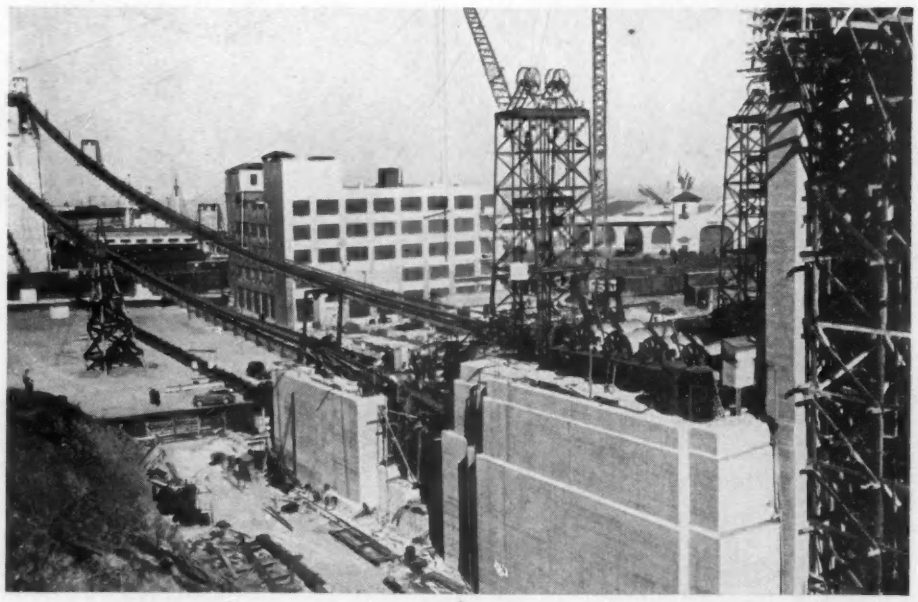
Tunnel through Yerba Buena Island showing manner of boring.

A tunnel through Yerba Buena Island is used to connect the East and West spans. This tunnel is the largest vehicular tunnel in the world, being 540 feet long, 76 feet wide, and 58 feet high.

The structure over the East Channel, east of the Island, consists of one main cantilever span 1,400 feet in length, with two 510 foot anchor arms. A cantilever bridge always touches on four points, two in compression and two in tension. These points act much the same as the points of a lever; the fulcrum acting as the compression point, and the weight, which holds the structure in position, acting as the tension point. The procedure may be adequately illustrated by a coal shovel; the force of the handle acting in tension and the fulcrum on the mid-point of the handle acting in compression.

East of the cantilever span, the bridge is continued by five simple truss spans, each being 509 feet in length, and 14 smaller spans 291 feet in length. Spans such as these are composed of much the same principal parts as the cantilever, mainly the tension and the compression points.

Foundations for the San Francisco-Oakland Bay bridge range from 105 to 245 feet below water, the deepest being below the easterly end of the cantilever span. The building of this deepest foundation is connected with the ambitions of a certain engineer, who realized that the pier with which he was working was being sunk to a considerable depth. The engineer therefore phoned to what was then the deepest pier on the bridge and inquired as to its depth. On learning that the other pier was 220 feet below water, he proceeded to dredge his hole 15 feet further down and hence had the deepest pier in the world.



A cable anchorage,

Towers on one of the suspension bridges are 474 feet high and on the other, they are 519 feet in height. These towers support cables 28 and three-quarters inches in diameter. Seventeen thousand four hundred and sixty-four individual wires are used in each cable, making a total of 70,815 miles of wire, nearly three times the circumference of the earth.

The entire structure is to be double decked, with six lanes for automobile traffic on the upper deck, and five lanes for truck and interurban electric lines on the lower deck.

A spectacular system of sodium lights will provide illumination. These lights will provide more than 8,000,000 lumens of highly efficient golden yellow illumination. Over

(*Continued on page 23*)

A Study of

GEOLOGY

In China

By ***FREDERICK G. CLAPP***
Consulting Engineer

MOST modern nations maintain geological surveys, and every great library bears witness to the fact that certain organizations of that sort have existed for nearly one hundred years, although not in every case under a consistent organic name. Work of a scientific or engineering nature has been less intensive in the Continent of Asia than elsewhere in the world; yet flood prevention commenced in China in the year 2297 B.C. under Emperor Yu, who is reputed to have deepened the river beds and cut channels to carry away devastating torrents.

Again, in Iran, *kanats* or subterranean aqueducts have been excavated in gravel fans of the vast interior plateaus for many centuries past. Still earlier a widespread deposit of sediment in Mesopotamia covered ancient pavements in some places, thereby enabling modern geologists and archaeologists to prove the truth of the Biblical flood. The falling of the walls of Jericho in the Jordan Valley was presumably due to earthquakes. Sodom and Gomorrah at the south end of the Dead Sea were destroyed by vast outbursts of petroliferous material of which evidence still exists in the form of asphalt-cemented gravels on the plane of a fault or great earth displacement crossing a lateral stream valley. More than six thousand years ago some ancient Aryan tribes, invading Iran from the northeast, may have been split by the substantial buttresses of upfolded Elburz Ranges, so that migration continued westward along two diverse routes.

Thus the fact that geologic conditions have controlled history from the beginning may nowhere be more obvious than in Asia. We need not search modern mines for a record of geologic effects on industrial efforts, for ancient mines of the Arabeh on the flanks of Mount Seir in southern Transjordan furnished copper in Solomon's time. Anatolia and Malaya provided metal for fashioning personal ornaments, idols, weapons and agricultural implements as early as the third millennium B.C. The writer has in his possession a bronze object of unknown date (but certainly fabricated between 2,800 and 4,500 years ago), reputed by archeologists to be a battle-adze, taken by some curio dealer from a grave in Luristan in western Iran; this implement is almost an exact model of a miner's pick of today.

Iron, too, was early known in the East, for immense blocks of wall limestone in the palace and hewn foundations of Persepolis (built by Darius the Great in the sixth century B.C.) are found fastened together by long iron staples having short ends—now badly rusted—, abundant in recently excavated ruins of the great Achaemenian capital.

Although writers continue to set forth the supposedly vast mineral richness of the Asiatic Continent—notably poor China—their view may be quite incorrect. Despite the gold deposits of the Urals and Siberia, most of Solomon's riches are supposed by geologists to have come from Africa and that of present-day Indian princes from all over the world. Plutarch states that the portable wealth of ancient Persepolis was equivalent to about $130,000,000—so enormous a sum that ten thousand mule carts and five thousand camels were used by Alexander the Great to transport the loot after the fall of Darius' capital. We are told that when this treasure was distributed the effect on the commerce of the civilized world was tremendous, indicating that gold and precious stones were not hoarded away in any single place immediately thereafter. Mining geologists have studied in great detail the coal resources of China and Turkey, the copper of Turkey and Transjordan, tin of the Malay States, antimony of China and a host of mineral substances in Soviet Russia. Ancient oriental literature mentions an abundance of rare jewels in the courts of Iran, China and Hindustan. Such precious stones as remain in those countries to the present time are of great beauty and value. The collection belonging to the former Turkish sultan, now on exhibition in the great National Museum of Istanboul, attests this fact. The Peacock Throne, in the Gulistan Palace at Teheran, contains rubies and emeralds not far inferior. If collections of the former Russian czars were derived in part from Asia, and if the Imperial Court at Peking accumulated enormous values in precious stones, these facts seem to bear witness to Asia's one-time mineral wealth. Occasionally

Illustrations courtesy of the the American Geographical Society.

The Yellow River looking downstream from Chingshuikwan between Shansi and Shensi Provinces.

valuable specimens of precious jades, sapphires, rubies and emeralds appear in Oriental bazaars. Some of the sources of these gems are known, but most of them have never been identified.

It appears, however, that, although Asia as a whole has in the past furnished valuable mineral wealth, this may not constitute an undue proportion of the undeveloped reserves of the rest of the world in the present century. The far north of Manchuria has produced only a small amount of gold, and Mongolia's metallic resources, aside from iron, are not great. Few mines of precious metals are actually known in Asia outside of the U.S.S.R., although numerous abandoned prospects appear throughout China, Iran and Turkey.

Carts hawling stores on road in Urga, Mongolia in 1913.

An impression has come down through history that China contains unlimited reserves of iron and coal. That opinion was catered to by Baron von Richtofen who traversed the "Middle Kingdom" in 1877–1883, but later visitors have disputed this view. The present writer, in 1914, when exploring northeastern China in the trapezoidal area between Dolonnor, Shanhaikwan, Peiping and Kalgan, found few minerals.

Large coal mines exist in North China just inside the Great Wall, but the greater part of the area is made up, like New England, of the roots of mountains from which the mineral veins were long ago eroded by natural agencies. Shansi and Shensi Provinces were found locally to contain valuable coal deposits. In fact, Chinese coal constitutes a vast reserve, although less in the aggregate than was formerly supposed—possibly only 250,000,000,000 tons. Turkey and Iran contain coal of limited tonnage and medium grade; but most Asiatic countries have no coal of their own.

The Kailan coal resources in northern Hopei are estimated over 680 million tons or nearly 80 per cent of China's estimated reserves. The other coal reserves of China, in Shansi, Shensi, Hopei, Shantung and Honan are estimated at about 200 million tons; these provinces having produced 14,500,000 tons in 1932. It seems probable that the Japanese realize the need of this coal for smelting iron ore which they now control.

The iron mines of Shansi Province were long reputed immense; yet the ferruginous beds are largely of low grade and are thinner than demanded by modern industry. Massive iron-ore is known in some parts of China and Iran, so that some persons have described "mountains" of this metal, whereas others have used the much-abused word "unlimited" in a similar connection; neither of these terms is warranted by present knowledge. Manchuria is reported to contain one billion tons of iron-ore reserves, having an estimated metallic content of over 300 million tons, but the rest of China may have only ore of varied quality.

When we come to the subject of petroleum, we are confronted by a mass of data; for several nations—Soviet Russia (both European and Asiatic), Arabia, India, Iran and Iraq contain vast reserves. Those of the last two named countries alone are recognized by geologists as amounting to more than four billion barrels and the estimated reserves of Asiatic Russia are even greater. In addition, China and Japan (including Sakhalien and Formosa) contain some oil, produced on a small scale, and Palestine and Turkey carry important surface manifestations. The unmined petroleum reserves of Asia may be a score of billion barrels.

Naturally, a continent having notable metallic and nonmetallic reserves has witnessed numerous efforts to study and develop them. In recent years the Soviet Government alone has sent hundreds of economic and scientific parties to report on its raw material supply. The Indian Government has efficiently deciphered its own territory in this respect. China had a geological survey for many years. Even the tiny mandated country of Palestine maintains a governmental geologist. Turkey, Iraq, and Iran have in turn employed geological advisers from time to time in recent years. Siam, also, at one time employed an American oil geologist to investigate the existence of petroleum.

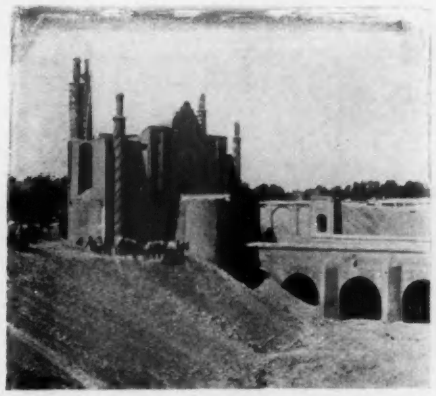
At one time the Government of Iran contemplated an extensive survey in search of oil and minerals in areas not now under development. This gave the writer an opportunity to see much of that ancient Empire—its intensely interesting geology, unusual types of physical geography, and endless archaeological wonders. Iran, in some respects one of the most interesting parts of the world, is now progressing rapidly under the guidance of a highly patriotic and far-sighted Shah. The writer was called to advise as to terms of a new oil concession intended to replace one that had just been cancelled. Governments in other parts of the world have likewise occasionally engaged American geologists to advise on contemplated mining and petroleum laws and concessions. Expeditions such as those of the American Museum of Natural History to the Gobi desert and that of the Carnegie Institu-

The Clapp geological party crossing a "loess bridge" (knife-edge divide) near Yenchang, Shensi Province, China.

tion of Washington across central China carried geologists far afield. Such studies in Asia are, therefore, not in their infancy.

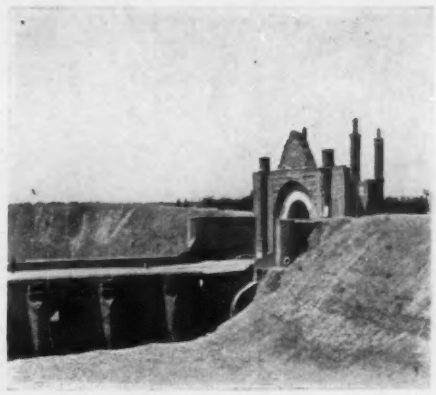
Aside from various attempts of governments to appraise their resources, concessionnaires or foreign concerns have sent their geologists to report on the possibilities of interesting areas. Long before the outbreak of the Great War European geologists of several nationalities roamed Anatolia, Mesopotamia, and the Levant. Adjustments in international frontiers were more than once cleverly manipulated following such investigations. Geologists of oil companies penetrated Turkey, Siam, Arabia, Iraq, India, and China.

The present writer was privileged to conduct a number of such explorations. In order to ascertain whether areas were worth testing by means of wells, it was necessary to send five geological parties, reinforced by as many more of a topographic nature, to map the surface of hundreds of thousands of square miles in North China as far west as Eastern Kansu. The equipment of such a comprehensive expedition alone was an expensive undertaking, necessitating the employment of men known to be competent for the specific work in hand. Besides, the linquistic difficulties necessitated maintaining interpreters in every field party, and the Government insisted on sending its representatives in addition. This occurred at a time when internal conditions of the country were greatly disturbed, so that a military escort of from two or three soldiers



up to sometimes a company of fifty was insisted on by the central and provincial governments. Reconnaissances and detailed surveys involved months of time; but in due course the field notes were correlated, the significance of observations determined, surveys set forth on maps and final recommendations made.

Nevertheless geologic work in Asia is still in its infancy; certainly much more must be done before the reserves of petroleum or any other mineral substance can be known with any degree of certainty. Asiatic nations are advancing toward higher civilizations and a progressive Asia requires all classes of raw materials, which can only be discovered by diligently pushing intensive studies on the part of governments as well as of scientific and commercial interests. When we realize that, even in the United States, neither mines nor oil wells are often developed on a large scale except through co-operation and assiduous exploration by both public and private agencies covering many years, we may understand that far more work must be done on the Asiatic Continent than has been authorized in the past. This may come through nationalistic progress



of the countries themselves or by the granting of concessions under which Europeans or Americans will explore at their own expense in consideration of ensuing contract privileges. Not one one-thousandth part of the continent has been explored geologically, and (outside of a few oil-fields developed by Americans and British and possibly somewhere by Russians) not one field party is operating under the sort of up-to-date technical methods that are now deemed essential by thousands of geologists in the United States. If Asia wishes to discover its hidden resources, it must adopt modern methods wholeheartedly.

It might be supposed that, in geologic knowledge and methods, Asia in the year A.D. 1936 would be where the United States was fifty years ago, as we of the Occident are wont to say of most Oriental activities—scientific or technical. But that is not exactly the situation. While some great Oriental Nations do not yet maintain geological surveys and have never been systematically studied by mining or oil companies or scientific societies, there are places where intensive detailed work has been done in economic and engineering geology. In the developed Iranian oil fields, for example, every minute detail of rock structure and stratigraphy has been mapped by skilled geologists and topographers. The Iranian, Bahrein, and Burman fields have been likewise carefully deciphered and large unproductive areas in a dozen nations have been exhaustively studied.

Far less is known of Asia than of North or South America or Europe. Earth problems may not be so much greater, but systematic studies are starting a few decades later. The problems that confront us as regards that continent are vast and fundamental. The accumulated experience of the world's best informed geologists and geophysicists is needed to solve them. It is reasonable that companies and men who successfully operated in North or South American mines or oil fields can, if given the opportunity, accomplish much for the development and prosperity of Asia.

Illustrations are of Tehran and the Elburz.

Opportunities Awaiting

THE CIVIL ENGINEER

In Underbuilt America

By GEORGE T. SEABURY
Secretary A.S.C.E.

FORTY thousand civil engineers unemployed in 1933; None unemployed now! Both of these statements doubtless require modification but they are not greatly in error. How did it all come about and what are the prospects for the future?

It came about this way. In 1929 culminated a wave of speculation. It had been developing for several years. The buying power of the country was large. Investments appeared to yield large profits. "Easy come—easy go." Incidentally construction of private, industrial and community facilities was large, approximately $9,000,000,000 a year. Then in October 1929 came the crash. Everything seemed to have been pyramided on borrowed money. Need for cash called for instant sales of securities at lowered prices. These wiped out margins and there seemed to be no bottom. Private construction stopped short. Public construction ceased as contracts terminated. The banks refused to lend to communities. Nobody had any cash and a tax-complex developed which resulted in the determination that no more construction should be undertaken. A $9,000,000,000 industry faded, to almost nothing. Result—unemployment. More unemployment in the industries as they ceased production or became bankrupt. More unemployment in the "Service" groups. Less buying power—and there we were in 1933—millions of wage earners (estimates vary) without pay envelopes and among them, 40% of the civil engineers of the country.

It is not to be inferred that the collapse of the construction industry was the cause of the depression. It was not, but it was one of the victims of the situation, and by a special combination of circumstances, suffered perhaps more slowly but certainly most intensely. It appears that architects have suffered unemployment more than any other trade or professional group. For them it has been a long, hard strain. Just where, in the groups of artists, musicians, actors and others of technical training, would be found engineers in general or civil engineers in particular there are no reliable figures to show, but it is certain that no large industry, wherein were involved architects, civil engineers, contractors, skilled and unskilled construction labor and producers of construction materials, felt the depression, nor contributed to unemployment so keenly and so directly, as did the construction industry.

The American Society of Civil Engineers deemed it as its duty to determine what was happening and if possible to determine what could be done to assist in the general situation. It was obvious that more pay envelopes with money in them would be of help. Community facilities were useful and worthwhile. They represented real wealth productive, directly and indirectly, of valuable returns. A good pavement reduces waste in every vehicle that traverses it. Now or improved water supplies or sewerage systems improve health. America is not overbuilt when people drink water contaminated by their own excreta. Nor is it overbuilt when without good roads they cannot bring their goods to market. To resume construction of useful and worthwhile community facilities would help to restore buying power. The Board of Direction of the American Society, therefore, recommended and urged the extension of Federal credit to States, Cities and to Counties to enable them to resume the construction of their useful and worthwhile community facilities. Such would be no panacea but it would be a mentorious palliative. This was in the spring of 1932.

Shortly thereafter Congress made provision for the Reconstruction Finance Corporation. It was really a banking institution and could extend credit only to projects that were self-liquidating without aid from taxation. Also projects, under these provisions, were to give evidence of being able to return all of the loan with interest. It helped the construction industry some but not much. Then came the Public Works Administration which liberalized the conditions. It required only that projects be useful and worthwhile. It extended a 30% grant and a 70% loan provided the credit of the borrower appeared good. Under P.W.A. large Federal projects also were undertaken wholly at Federal expense. It carried out its procedures in the normal manner; that is, using engineers to design, contractors to build and engineers to supervise and inspect. P.W.A. did much to stimulate construction but it was inhibited from the outset by competing Federal agencies.

Norris Dam under construction.

Dam project showing labor camp in background.

P.W.A. required security for its loans. C.W.A., F.E.R.A. and W.P.A. offered money relatively free. What incentive had states, cities and counties to borrow money when they were given reason to expect, later to get it free, or nearly so? The program of Federal aid to useful public works, properly designed and properly constructed, has never been given a fair chance to contribute its usefulness to the relief of unemployment and the wealth of the nation.

The American Society of Civil Engineers operates the Engineering Societies Employment Service jointly with the three other large engineering Societies. It has offices at New York, Chicago and San Francisco. In May, 1928, the trend of placements of engineers reversed itself at the New York office. Chicago had the same experience 9 months later, in February 1929. It was not until October, 1929, yet 8 months later that the same experience was felt at San Francisco, but these situations had little reference to civil engineers. Their moment of maximum employment and maximum pay was December 31, 1930. October 1, 1933, was the moment of greatest unemployment for Civil Engineers. In those two years and 9 months some 40,000 civil engineers were thrown out of employment, others, yet retained, were reduced in salaries or worked but part time. Engineers in private practice lost much or all of their business. The income of the profession is estimated to have shrunk so as to leave a residue of but from 30 to 40% of normal.

These were the conclusions of the Society's Committee on Salaries which made an extended survey from many sources. It observed the situation to be progressive and, without apparent basis, more influential than the arbitrary decision of public officials that here was a way to trim, a way incidentally with a maximum of approval from those tax-minded and a minimum of disapproval, at that time, from those politically-minded. In an effort to set the brakes against this rapidly progressing downward movement, the Committee issued reports in March, 1934 and August, 1934, on Prevailing Salaries of Civil Engineers. They were statistical analyses based on the salaries paid to 16,046 engineers in the highway departments of the several states, supplemented by the salaries of some 28,400 civil engineers engaged in other types of work. What effect this report had in decelerating the downward slide of engineers' salaries can never be fully appraised.

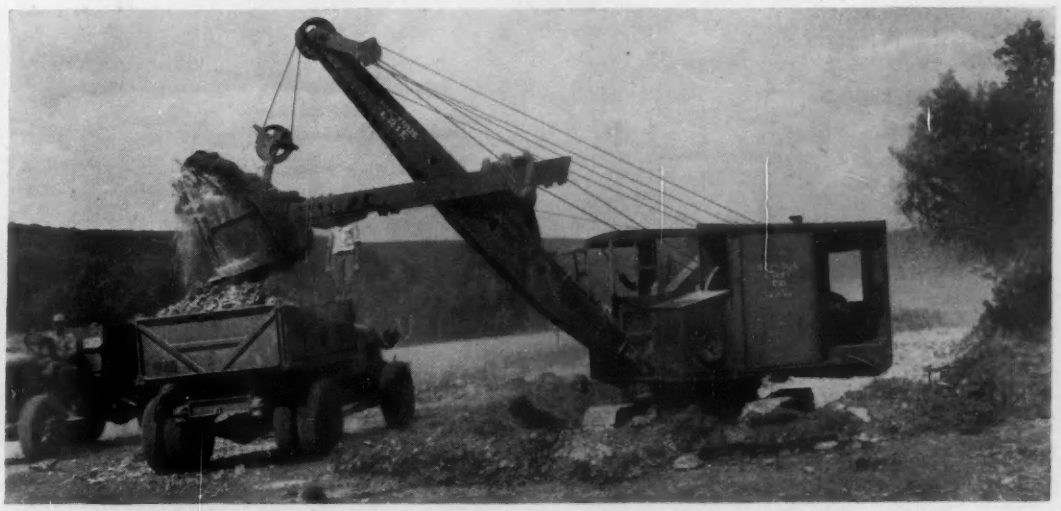
Re-employment of civil engineers in quantity began in October, 1933, when the hastily developed Civil Works Administration had need of engineers to supervise the field forces. It continued increasingly under the Federal Emergency Relief Administration and yet more rapidly under the Works Progress Administration. Meanwhile the R.F.C., and P.W.A., the T.V.A., the C.C.C., the Coast and Geodetic Survey, the Forest Service, the Bureau of Reclamation, the Corps of Engineers of the Army, the Bureau of Public Roads, and Bureau of Agriculture and yet other permanent or temporary Federal organizations called for more and more engineers.

At first the demand was for engineers of experience in the handling of men and use of construction materials—then for men of tested technical ability; and only rather lately for young men as yet without practical experience. The salaries paid were small for the qualifications required but were accepted without particular reservation. To be at work again was enough. To be at work again where one's experience was needed led to enthusiasm and disregard of working conditions. Engineers, it seems, are inherently constructive and would rather be doing than be idle. Hours of work and rates of pay seem to be quite secondary.

Here they are. Thousands of civil engineers newly employed in temporary Federal agencies on work that it is announced is soon to cease. Others, generally better situated, in other Governmental organizations, Federal, State, County and City. Others in so-called "private practice," either as

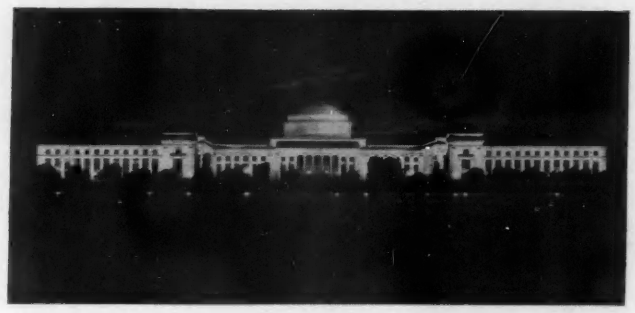
(*Continued on page 23*)

Excavating Engineer



This power shovel loading as much as a 1000 yds. per 10 hour shift gives illustration of excavating activities.

THE TECH ENGINEERING NEWS



THE MANAGING BOARD

H. ARTHUR ZIMMERMAN, '37
General Manager

JERVIS C. WEBB, '37
Editor-in-Chief

FRANCIS S. BUFFINGTON, '37
Business Manager

FRANK S. GARDNER, '38
Associate Editor

MURRAY H. HAYWARD, '38
Treasurer

HARRY O. SAUNDERS '38
Associate Editor

RICHARD A. NOVAK, '38
Advertising Manager

DALE F. MORGAN, '38
Associate Managing Editor

JOHN C. WHITE, '38
Circulation Manager

FRANK B. KEMP, '38
Associate Managing Editor

ROBERT L. JOHNSON, '38
Publicity Manager

Editorial Department

JAMES B. HESS, '38
Contributing Editor

JAMES H. OWENS, '37
Contributing Editor

DAVID A. WERBLIN, '36
Art Editor

JOHN B. ALLEN, '36
Art Editor

Business Department

DEMPSTER CHRISTENSON, '38
Associate Advertising Manager

WILLIAM WOODWARD, '38
Associate Advertising Manager

WALTER KAUFMAN, '38
Associate Circulation Manager

Staff

M. L. CUTLER, '39
J. J. DONOVAN, '39
A. B. SHALER, '39
C. N. LEVY, '39
B. W. WHEELER, '39
R. D. SPEAS, '39
I. PESKOE, '39
P. B. FARWELL, '39
H. CHESTNUT, '39
A. A. DEVOE, '39
F. MULBERRY, '39

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, LEONARD H. CHURCH
1510 Hanna Building, Cleveland, Ohio

Arkansas Engineer
Colorado Engineer
Cornell Engineer
Illinois Technograph
Iowa Engineer
Iowa Transit
Kansas Engineer
Kansas State Engineer
Marquette Engineer
Michigan Technic
Minnesota Techno-Log
Nebraska Blue Print
New York University Quadrangle
North Dakota State Engineer
Ohio State Engineer
Oregon State Technical Record
Penn State Engineer
Pennsylvania Triangle
Purdue Engineer
Rose Technic
The Tech Engineering News
Villanova Engineer
Washington State Engineer
Wisconsin Engineer

EDITORIALS

COOPERATION VERSUS LIBERTY

NATIONAL planning, national regimentation, international cooperation, and world peace are commonly heard expressions. In all of them is implied some measure of cooperation. Cooperation, however, involves a further implication, namely a sacrifice of a portion of the individual liberty. Such a sacrifice is, in reality, a restraint of a natural primative instinct, an instinct born of the comparatively complete independence of primeval man from his fellows.

With respect to his environment, man has never been free; his life has been a succession of attempts to combat or adapt himself to the physical conditions in which he has been situated. On the other hand, man's freedom with respect to other members of his species, although originally large, has decreased in proportion to the growth of society. Amidst an increasingly complex social structure, he has had to yield more and more of his customs of independence, that is, he has had continually to impose a greater restraint on his primative habits.

It is thus apparent that the essential difference between barbarism and civilization is one of restraint. It is also apparent that any further development of civilization entails a further restraint. Such things as national planning and international cooperation, which must be interpreted as attempted developments of civilization because they strive to improve men's relations in a highly complex society, demand an increased restraint. The controversies arising from their introduction or from the details of their administration are the growing pains of civilization. Those who introduce such influences must consider what restraints of liberty they are simultaneously introducing; while man himself must consider whether or not, by accepting or refusing such restraints, he wishes to become more or less civilized.

THE UNIFICATION OF SCIENCE

ONE night, after he had listened to a very abstruse and specialized lecture on atomic polarization, the tired scientist had a dream. It came to him in the following way.

He felt himself lying on his back on the damp brown earth, fettered with innumerable steel cables, so fine he could hardly see them. But an irresistible force was drawing him upwards. His whole body strained at the cables. And then, he was separated from his useless body, and swiftly rose into the pale silver firmament. He was in Nirvana. Slowly beneath him, very slowly, the silver-gray mist lifted. Dimly he could see

the outline of a great city. Gradually as he looked at it the city resolved itself into a honeycomb formation of small polygonal sections separated from each other by high walls, which were casting dull gray shadows on the streets beneath them. Soon, however, he distinguished small groups of creatures armed with implements of all types attempting courageously to break through the walls. Now and then, a group would succeed. Then the avalanche of material would throw them back. But they went ever forward, until finally all the walls had been destroyed. From then on the work of reorganizing the city was carried on rapidly, until everything was moving with order and progress.

Then the mist covered the vision again. Perhect happiness became his. He had seen Truth. The city itself was the city of Truth. The sections were the various departments dedicated to the discovery of Truth. The groups were those who are valiantly trying to break down the high walls that keep the sciences apart, each in its own little special subject.

The way to Progress is to break down the divisions between the departments of science, so that the Philosophy of Truth can enlarge itself, culminating eventually in that inaccessible goal of all real men: absolute Truth. In the last decade, enormous advances have been made in this direction, and it is up to us, engineers and scientists, to fight courageously towards the unification of science, the only method by which real Truth may be attained.

THE CO MENACE

LAST year there were half a million highway accidents in this country, the causes of which were unexplained. In an attempt to account for this large figure, evidence has recently been published which points an accusing finger, not at recklessness or liquor, but at carbon monoxide. The possibility of this deadly gas accumulating in a car, moving in the open, has been generally overlooked. Actually, in deficient cars, carbon monoxide does find its way into the driver's compartment. The driver, after being subjected to even a low concentration for a fairly long time, becomes groggy or eventually is asphyxiated. With present day high speed cars, such impairment of the driver's faculties is bound to be a cause of fatal collisions.

The driver's cooperation is also needed to solve the problem. Of course, winter driving is more comfortable with the windows shut, but it is by no means as safe. A long winter drive, with the windows closed, has been known to produce headaches and even asphyxiations. Exposure to a *low concentration for a long time* is most harmful. Tests made at random along the highways, by an oil company, showed that one car in twenty contained a dangerous concentration of carbon monoxide. For this reason, the National Safety Council has proposed the rule that motorists, on long drives, stop occasionally for a "breathing spell" in the open.

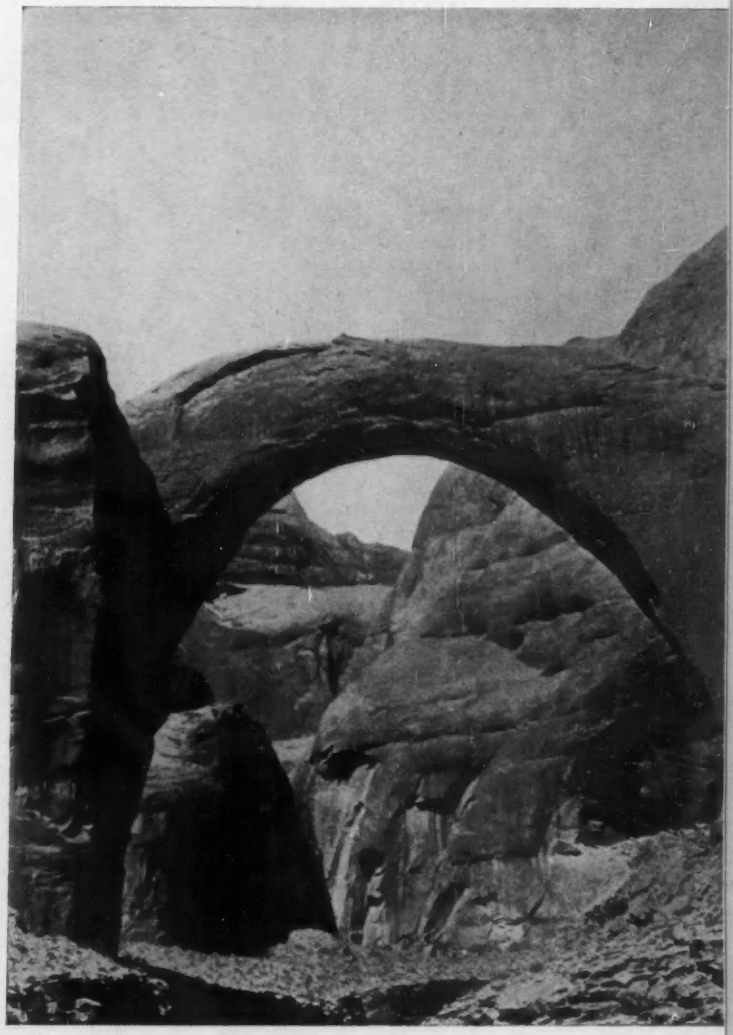
Until the time is reached when this hazard has been definitely removed, the individual motorist must investigate this danger himself. Fortunately, the trouble is easily remedied at a garage. To keep at least one window partly open is most important, even if the carbon monoxide concentration is known to be low. Otherwise the driver becomes just as much a menace as a drunkard.

The source of the carbon monoxide in most cases is in the defective equipment of the car. Almost all states now have compulsory car inspections, but in them, the carbon monoxide question is completely neglected. The obvious remedy is the inclusion of a test for the carbon monoxide concentration in the compulsory state inspections.

A CASE FOR AIR TRAVEL

RECENTLY public fears concerning the safety of air travel has reached "a new high." The reason for this lack of confidence is not difficult to fathom in view of the detrimental publicity, much of it unmerited, in which the accidents and near accidents of the airlines are played up by the newspapers and radio programs. Perhaps the best way to obtain a true picture of the comparative safety of different means of travel is to turn to the Department of Commerce, a body established to give assistance impartially to all forms of transportation and which has in the course of its existence assembled a complete set of statistics in regard to safety in travel. In their statistics the Department uses passenger miles as an equitable means of comparison. The latest records available show that in the first half of 1935 the airlines flew 40,714,686 passenger-miles per passenger fatality while there was a fatality for every 11,300,000 passenger miles traveled on the highways by private automobiles.

One of the most substantial aids to the safety educational efforts came recently in the form of a letter from a large, nationally known insurance company, which said in part: "This company has, on a basis of experience, promulgated a ruling that executives or salesmen traveling by air on regularly established air lines are to be classified as 'A,' whereas executives or salesmen traveling by automobile are to be classed as 'B' risks. This is made necessary by the fact that, in our opinion, transportation by air does not present hazards comparable with those incident to the use of an automobile".



ENGINEERING DIGEST

NEW WALL 'PHONE

A NEW bakelite wall telephone, combining advantages of wall-type instruments with the convenience of the modern handset, has recently been introduced by the American Automatic Sales Corp. The working parts of this instrument are all mounted on the one piece bakelite base, so the cover may be removed by withdrawing the cradle plunger assembly and loosening the cover screws, leaving the remainder of the assembly undisturbed. The cover itself carries no wiring—a new feature in wall telephone design.

This new instrument is available with dial for automatic service, or with a dial cover plate for manual service, this plate being replacable with a dial at any time. The dial is mounted above the handset cradle, which is so shaped that the handset is removed by pulling forward instead of lifting, thus avoiding interference with the dial.

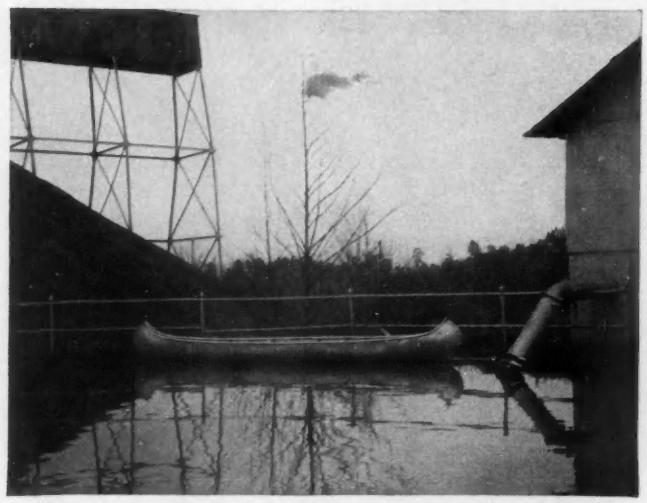
—Telephone Engineer

ALUMINUM CANOE

N oxy-acetylene operator recently designed an all aluminum canoe to be constructed by oxywelding. The hull of the canoe consists of ten strips of aluminum extending from one gunwale to the other welded together at the seams. The hull was reinforced by several cross pieces and by suitable reinforcements at the ends and edges.

When the operator had completed his work, the result was a graceful little craft that weighed only 83 pounds. Moreover, it was permanently leak-proof and corrosion-proof.

One further idea occurs in connection with this work. Through the use of the oxy-acetylene welding method of fabrication the design could be modified easily to incorporate the installation of air-tight and water-tight tanks. Such air tanks make a canoe difficult to overturn and make it non-sinkable. This would be an added advantage in a canoe intended for use in rough water.



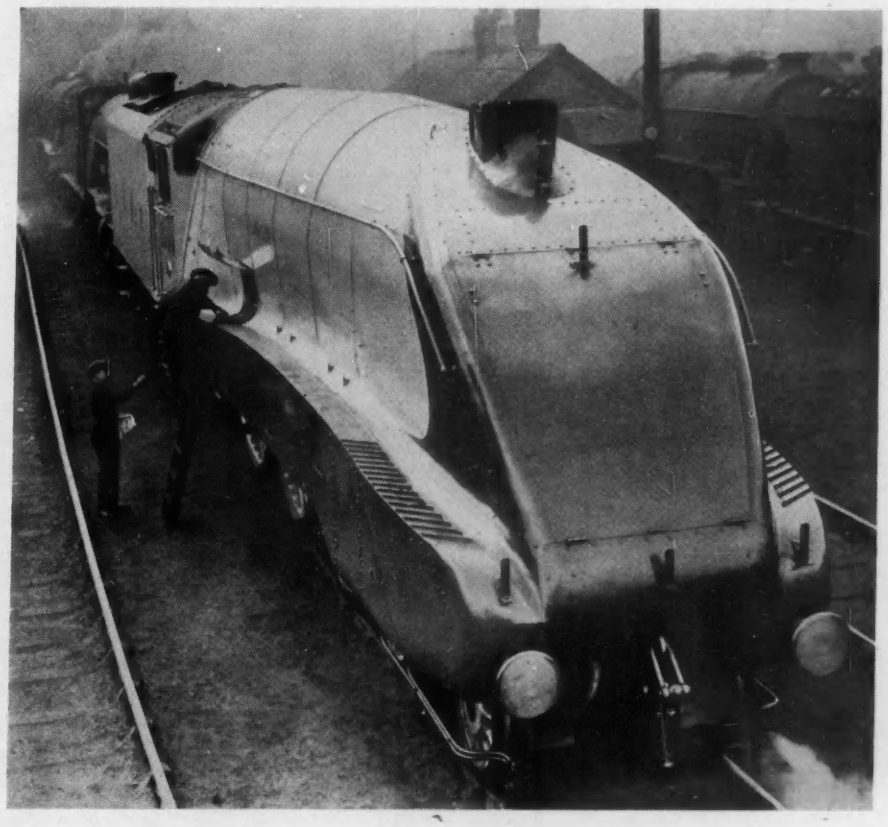
This welding of a very light boat brings to mind the varied applications to which welding is now put. Probably one of the most notable examples of field fabrication in recent years was the construction of the pen-stocks for Boulder Dam. Because of their huge size, it was, of course, impossible to fabricate them elsewhere and ship them to the job. The penstocks ranged from 13 ft. to 30 ft. in diameter, and from $\frac{5}{8}$ in. to $4\frac{1}{2}$ in. in thickness. It is obvious that there were many problems in cutting to be solved. To further complicate this, none of the plates were flat, all of them were curved in two directions. However, by the ingenious adaptation of a standard portable shape cutting machine it was possible to fabricate and prepare the edges of these plates for welding without the need for any subsequent machining or preparation.—*Oxy-Acetylene Tips*

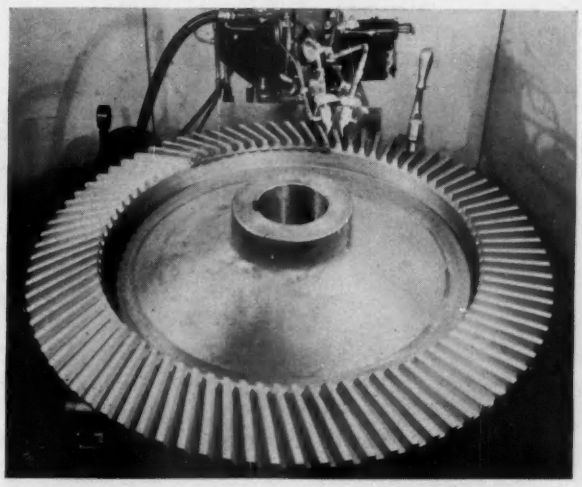
FLAME HARDENING

ALTHOUGH in the development stage as late as 1933, mechanized flame hardening has rapidly materialized into commercial proportions. Illustrated is a new universal machine operating on this and built for surface hardening large bevel gear teeth. This is another example of an idea in the mechanical field that rapidly found its way into the design of a machine.

The process as carried out by the new unit, opens the way to accurate and uniform surface hardening by means of the oxy-acetylene flame. An important advantage is the simultaneous hardening of both sides of the tooth. Previous methods are said to have been mostly single-side hardening processes which introduced the danger of drawing or checking the opposite side. Quenching is accomplished by two small water streams directly behind the flame.

Hydraulic control embodied in the design facilitates variable speed of travel so that uniform heating of a section of tapering thickness is possible. It also allows speeding up at both ends to prevent overheating of the corners of the teeth. A wearing surface equal to case hardening can be obtained, and penetration can be varied to almost any desired amount by adjusting the speed of travel.—*Machine Design*





ENGLISH STREAMLINER

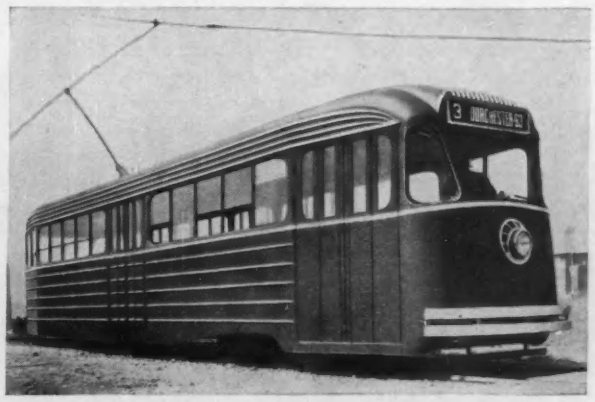
THE London and North Eastern of Great Britain is the possessor of the big steam locomotive illustrated. This locomotive, the Silver Link, is a part of their streamlined train, the Silver Jubilee, so named in commemoration of the twenty-fifth year of the reign of George V. The train consists of this locomotive and three articulated sections—one of three units, and two of two units each. One of the two unit sections is for first class passengers, the other for third class passengers; they are separated by the three unit section of two diners with the kitchen between.

This train has attained a speed, in tests, of 112 miles per hour and is scheduled to make the run from King's Cross (London) to Newcastle, a distance of 268 miles, in four hours, with a stop at Darlington. The trip from London to Darlington is the fastest scheduled run over a distance of over 200 miles.—*Railway Mechanical Engineer*

4.75 MPHPS.

INCORPORATING new features of design and construction, 100 new surface cars for the Brooklyn and Queens Transit System will accelerate at a rate of 4.75 miles per hour per second. In 5 seconds they can reach almost 17 mph, and can attain 25 mph in less than 11 seconds. The new cars, equipped with a floating-type control, will accelerate safely as well as smoothly since the cars also are outstanding in their braking equipment. The brakes will be of 3 types—working on the motors, the wheels, and the tracks—which give the cars a deceleration of 8 miles per hour per second, or enable them to stop in less than 100 feet when going 32 miles per hour. Each car will have four 55 horse-power motors.

—*General Electric Review*



RESEARCH IN REVIEW

COURSE XVI — Aeronautical Engineering

TO increase the general knowledge of airplane engine performance a research program of some length has been inaugurated under the auspices of the National Advisory Committee for Aeronautics in co-operation with the Automotive Engine Laboratory.

This program includes two problems; the first is the design of the two-stroke, or more popularly called two-cycle, engine for aircraft. At present the design of the two-stroke engine presents much greater difficulty than the conventional four-stroke type, largely because the burned gases cannot be forced out of the cylinder by means of the piston but must be displaced by the incoming charge, a process known as "scavengering." The expulsion of the burned gases must be accomplished with a minimum amount of mixing of the burned and unburned charges and with a minimum loss of the fresh charge out of the open exhaust valve. A successfully designed two-stroke engine would have the advantage of obtaining one power impulse per revolution instead of one in two revolutions as in the four-stroke engine. In addition, the ported two-stroke engine is perhaps the simplest prime mover known and is consequently inexpensive to manufacture. It is hoped that the results of this investigation will indicate the possibilities of the two-stroke engine.

The Engine Laboratory is particularly well fitted to carry out this investigation because of the work previously done here on direct fuel injection which definitely improves the fuel consumption and control of the two-stroke engines, and because of the availibility of the new indicator which is invaluable for investigating the charging of the cylinder.

The second investigation is that of the dynamic characteristics of the induction system of conventional engines. Because of the inertia of its mass, the air in the inlet pipe of an engine tends to continue its flow after it is once started. Utilizing this inertia, it is possible, without supercharging, to fill the cylinder of an engine with air at several pounds higher than atmospheric pressure and thereby increase the output of the engine. The Automotive Engine Laboratory has been engaged in work along these lines for some time with a high degree of success. By proper regard for the dynamics of the inlet system it has been found possible to achieve the effects of a moderate degree of supercharging. The results of this work are already having their effect upon modern aircraft engine design, and it is hoped that the completion of this work will make complete data for the design of the induction system available to engine designers.

COURSE I — Civil Engineering

A NEW machine making it possible to duplicate in the laboratory the motions of destructive earthquakes directly from seismograph records has been built in the Department of Civil Engineering. The new machine will be used to study the destructive effects of earthquakes on buildings and other structures by means of scale models.

The engineer's primary interest in earthquakes is from the surface of the earth upward. His problem is not only to faithfully duplicate the motions of earthquakes in the laboratory, but to study their effects on models and design structures to resist them.

The new earthquake machine was designed by Arthur C. Ruge, in consultation with Dr. Vannevar Bush. The general principles and operation are relatively simple.

A "shadowgraph," which is really an optical cam, is made from an actual seismogram by cutting the record out along the wavy line which represents the wave-motion of the quake. The shadowgraph is then passed before the electric "eye" of the machine. An electric analyzing device, coupled to the "eye," performs the function of a brain and controls the machine in such a way that it is forced to follow the wavy line as the shadowgraph moves along. Thus the motion of any recorded earthquake may be duplicated by placing a shadowgraph record in the machine.

The primary driving power of the earthquake machine is obtained from oil under pressure working against a piston connected to a platform which is free to move in any direction. The electric analyzing device controls a valve which feeds the oil into the piston chamber. This valve is moved in exactly the same way that a radio receiver moves the diaphragm of a dynamic loud speaker, only the force available for moving the valve can reach a maximum of nearly fifty pounds, and consequently it can move fast.

One of the interesting features of this machine, which is called a "shaking table," is that although it can produce forces of over two thousand pounds when necessary, it produces only the amount of force needed to make it follow the shadowgraph properly. If a model is being shaken on the table, the machine's "thinking" device automatically regulates the forces on the machine in such a way that the reaction, or "back kick," of the model does not change its motion from the required path.

With enlargement of the Cape Cod Canal in progress, research engineers are making an advance study of the tidal currents that may be expected when this important coastal waterway is finished. The investigation, which involves complex research methods and precise measurements, is being carried on in a huge scale model of the canal and its approcahes, Cape Cod and Buzzards Bays, with unique facilities for duplicating in miniature the tidal conditions encountered in the present canal.

The complex nature of the investigation is indicated by the fact that the average rise and fall of the tide in Cape Cod Bay is five feet greater than in Buzzards Bay, a distance of 13 miles through the canal. There is also a tide time difference of three hours between the bays. As a result, the tide in Buzzards Bay is rising while the sea is still falling in Cape Cod Bay, and the tide in Buzzards Bay begins to ebb several hours before high water at the other end of the canal.

Occasionally, under unusual conditions of flood tide, driven by high winds, maximum differences in level of nine feet between the bays may occur. At high tide in Cape Cod Bay the water rushes westward through the canal to the lower level in Buzzards Bay. Six hours later the current reverses and flows swiftly east. Under ordinary conditions the maximum velocity of these currents exceeds three miles an hour, while during storms it may reach nearly five miles an hour.

The model is built to a scale of approximately nine feet to the mile, and is constructed of concrete and sand to form a channel accurately reproducing the curving path of the canal across Cape Cod. The reproduction of Buzzards Bay alone, with its numerous inlets and islands, occupies a space 35 by 50 feet.

Enlargement of the canal is expected to change the sea levels at both ends of the canal and to alter the velocities of currents through the waterway. At present water flows through the canal at approximately 13,500,000 gallons per minute. After enlargement the flow is expected to be at least 75,000,000 gallons per minute. Scientific devices accurately reproduce in miniature the ebb and flow of the tides, and sensitive instruments arranged along the canal record the effect of currents and wave motion.

COURSE VI — Electrical Engineering

INSULATING oil finds a wide application in the electrical industry. It has been estimated that in excess of two and one-half billions of dollars worth of electrical equipment, or approximately twenty per cent of the total investment of the electrical power utilities in this country, is dependent on oil insulation for its operation. In these applications the insulating oil is subject to chemical reactions due to its contact with other insulating materials, metals, and air, and is subject to action of heat and electrical stresses. It is therefore very important to study the electrical, chemical, and physical characteristics of insulating oils.

The Electrical Engineering Department has recently started a joint research project with the Edison Research Co-ordinating Council of the Association of Edison Illuminating Companies. The object of this investigation is to disclose the mechanism by which the characteristics of insulating oils may be determined by processes related to oxidation, with special reference to its influence on electrical characteristics. The investigation further involves the development of tests for quantitatively determining the extent of deterioration, and a study of the influence on deterioration of normal and added constituents of commercially refined insulating oils and of materials frequently in contact with the oil during service.

COURSE X — Chemical Engineering

PROFESSOR HOTTEL is developing an instrument for measuring the heat distribution in furnaces where carefully controlled heat input is essential. The tube stills used in oil refining exemplify this condition, whether operating under vacuum in the distillation of heat-sensitive lubricating oils or under high pressure for cracking to produce gasoline. In the first case, uneven heating ruins the lubricating oil, while in the latter case it causes coke formation and subsequent splitting of the overheated tubes. An instrument, suitable for plant use, which measures the heat flow across any plane in the furnace has been devised and given preliminary tests. In principle, two parallel metal plates are exposed in the furnace and the heat flow across the plane of the plates is measured by determining the temperature of the two surfaces. The initial experiments indicate that the method will prove successful and are serving as a basis for improvements in the design of the instrument.

The combustion of solid fuels in powdered forms or on a grate and the similar problem of producing gas from solid fuels involve interaction between solid and gas at a rate which is largely controlled by purely physical processes of diffusion. Oxygen for combustion must diffuse in to the solid through its surrounding gas film, while the gaseous products of combustion must diffuse in a counter direction through the same film. The predominant importance of solid fuels to industry has incited many investigations of these phenomena, but work in the past has been restricted to observing overall effects and venturing deductions from these as to what occurred in the immediate vicinity of the burning particle. Two widely divergent theories have been upheld, but no one had the facts. In recent studies, micro-samples of gas have been drawn from points in the gas film at varying distances from the burning solid up to the carbon surface itself. These samples are analyzed with micro-equipment capable of determining the constituents in a sample of only 0.15 cubic centimeters as accurately as can be done by regular apparatus on samples 600 times as large. The results have given a clearer picture of the diffusion phenomena and of the effect of the variables involved. Further work, however, will be necessary before the reactions in a fuel bed can be quantitatively described.

COURSE III — Mining and Metallurgy

THE large scale upon which research upon the air conditioning of mines must be carried out requires that all data be taken in the mines. Much study, however, has been made in this field, and has been conducted under the direction of Professor Foster.

Pioneer work in the air conditioning of mines was conducted by the St. John del Ray Mining Company of Brazil at its Morro Vehho Gold Mine, when the workings reached depths exceeding 6000 feet. This company's refrigeration plant started operation in December 1920 with improved underground conditions resulting. Air entering the mine was cooled from 72° F. wet-bulb to 43° F. causing temperatures 6000 feet below to be reduced to 84° F. The efficiency of the workmen was greatly improved and mine production increased. Furthermore, the miners were more alert, the accident rate declined sharply, compensation rates became lower and the labor turnover was much reduced.

Today, on every hand, we hear of installations of air conditioning plants in theaters, public buildings, and even in private homes. Human comfort is the primary purpose of every such application. The mining industry, ever extending its operations to greater depths, has been forced to cool the air and control the humidity on its lower levels if million dollar plants are to maintain operation. Naturally, air conditioning allows the miner to work in more comfortable surroundings.

The deeper the mine, the hotter the air becomes. High rock temperatures account for a portion of this temperature increase, but the chief influencing factor is barometric pressure. In many of our deeper mines, temperatures of 100° F. and higher are encountered. It is possible to work at such temperatures if they are accompanied by low humidity, but such a condition seldom prevails underground for moisture is usually present either from natural sources or for combating dust. High temperatures, with nearly 100% humidity, reduce the efficiency of workmen to an absolute minimum.

Such conditions faced the St. John del Ray Company before it resorted to refrigeration of the ventilating air, and in the past few years several deep gold mines in South Africa and India have installed air conditioning plants to overcome similar working difficulties. The most recent unit has been installed at the Robinson Deep Mine in South Africa. The cost of this installation will approximate $500,000; 400,000 cubic feet of air entering the mine every minute will be cooled to about the freezing point and will reduce underground temperatures from 15° to 18° F. near the shaft. Transportation underground of 2100 tons of ice daily would be required to obtain this cooling effect. This figure is doubly interesting since but 1500 tons of gold ore are hoisted daily from the mine. The operation of this plant will permit the continuation of mining at a depth of 7500 feet under conditions similar to those encountered on the 6000-foot level.

UNTIL recently, steel has been practically the only alloy of which the properties could be materially improved by heat treatment. During the last few years, great progress has been made in the understanding of metals, and alloys have been developed in which increases of strength and hardness of 10 to 100 percent or more may be produced by suitable thermal process.

Duralumin, a commercially important light alloy composed essentially of aluminum, is a typical example. If it is annealed, or if it is quenched at about 500°C. in water and immediately measured, it has a tensile strength of about 35,000 pounds per square inch. However, after a few days at room temperature, this value increases to about 80,000 pounds per square inch. This behavior is called age hardening.

An alloy of copper containing two to three percent of

beryllium is another example. In the soft state after quenching, its tensil strength is about 80,000 pounds per square inch but, after aging, this tensil strength is doubled. This places it in a class with steel as a structural material, and like steel, it can be fabricated in the soft state and then hardened for service. Nickel alloys, zinc die casting alloys and the light alloys based on aluminum and magnesium show this property.

These useful alloys are being intensively studied at the present time, both from a theoretical and from a practical viewpoint. There is every reason to believe that in the future many of the useful properties of the non-ferrous alloys, such as color and resistance to corrosion, can be successfully combined with those properties of strength and hardness which are important in metal structure. In this way, a metal may be "custom built" to fulfill a wide variety of practical purposes.

COURSE V — Chemistry

IN an article published recently, Professor A. A. Morton with Daniel B. Clapp, G-V, announced the discovery of the cancer producing properties of two hydrocarbons, not previously known to be capable of causing malignant tumors. These organic compounds, named symmetrical tri-phenyl-benzene and tetra-phenyl-methane, resemble the formerly known carcinogenic hydrocarbons in that they are poly-nuclear; that is, their molecules contain several benzene rings. They differ in not having their benzene rings fused together as in the case of the phenanthrene and anthracene derivatives already known to be cancer-producing.

It turns out that tri-phenyl-benzene and tetra-phenyl-methane are the first known cancer-producing representatives of the respective series of hydrocarbons in which they are classified scientifically. This fact is particularily significant in that it widens the field of search for the existence of carcinogenic properties, to include compounds in which fused rings are completely absent.

The action of these compounds in causing tumorous growths is comparatively slow. This fact was shown by making the usual tests on specific strains of mice. After continuing weekly injections, for a year, of a solution of tri-phenyl-benzene in sesame oil, twelve out of sixty mice used in the test developed malignant tumors. Similar tests on twenty-five other mice, but using solutions of tetra-phenyl-methane in benzene, showed eight cases of epitheliomata (a type of cancer). While slow in developing, the percentage of positive test was comparatively high.

The new field, opened up by the work completed thus far, is being extended to determine more certainly whether or not the property of producing cancer lies in the benzene ring as influenced by substituents and, if so, to find the definite influence contributed by the nature of substituents and by their positions in the molecule.

Investigation of higher homologues of the two hydro-carbons already shown to give positive test, is likewise under way.

Asso. Member of Society of Automotive Engineers

JOSEPH WEINFIELD & SON

Automotive Engineers - Automobile Repairs

Telephone KIRkland 8341

73-83 VASSAR ST. CAMBRIDGE, MASS.

SIMPLEX WIRES and CABLES

for electrical transmission

Insulated with Rubber, Paper or Cambric

SIMPLEX WIRE & CABLE CO.

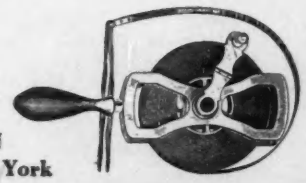
79 Sidney Street, Cambridge A

BOSTON, MASS.

You'll Like-- LUFKIN TAPES and RULES

For Engineering, Surveying, Construction, Mine or Highway Work— Lufkin Tapes will serve you best.

THE LUFKIN RULE CO. SAGINAW, MICHIGAN 106-110 Lafayette St., New York



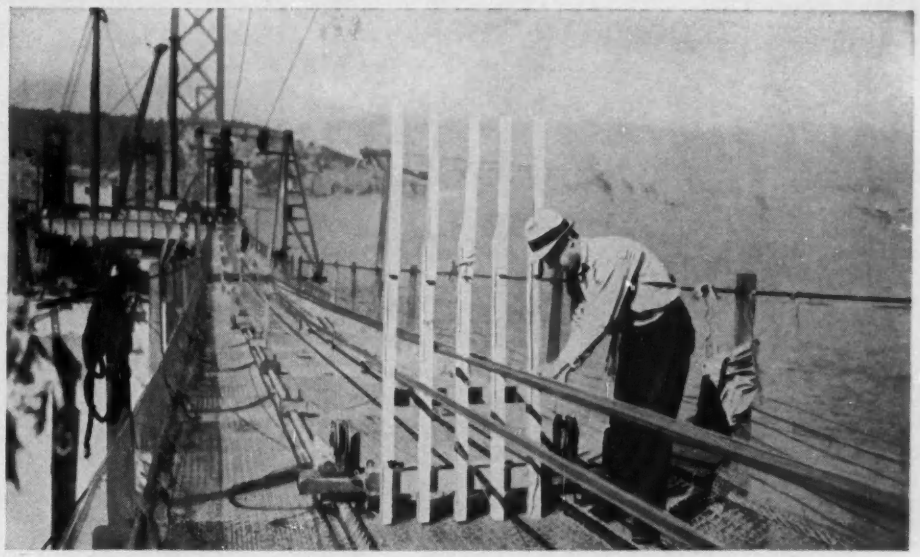
"FRISCO" BRIDGE

(*Continued from page 10*)

35 full moons would be required to give the same average intensity. A total of 16,000 sodium lights on 25 circuits will be strung along the 15 miles of roadway. The common type of incandescent light requires about 550 watts to produce 10,000 lumens, while the sodium light requires but 220 watts or less. The lamps have slightly more than 100 square inches of radiating surface, instead of the theoretical point source of the incandescent lights. This fact necessitates reflectors of decidedly different design. These are made of aluminum and are mounted horizontally in a combination of two parabolic and two plane mirrors, so arranged as to direct the light along the roadway. Most of the energy output in the sodium lamp is in the characteristic yellow color of sodium, giving the lamps a greater proportion of visible light to other radiated energy than that obtained with other light sources, and thus providing high luminous efficiency and a soft diffused glow of essentially a single color. Such qualities as these afford high visibility, freedom from glare, and economy of operation.

Although the San Francisco-Oakland Bay Bridge project is financed by a loan from the Federal Government the bridge is a California State enterprise, being built by the California Toll Bridge Authority, and costing the state approximately $77,200,000, the greatest amount that has ever been expended in any single structure. The Golden Gate Bridge, however, is not a state project, but is being constructed by the Golden Gate Bridge and Highway District at an estimated cost of $33,500,000. Both bridges will be toll bridges and self-liquidating enterprises. It is estimated that the entire cost of construction will be paid back by 1954 for the San Francisco-Oakland Bay Bridge, and in less than 35 years for the Golden Gate Bridge, by means of revenues derived from the use of the bridges and paid in the form of tolls collected from motorists and fares from interurban railway passengers.

Civil and construction engineering have been improving ever since the beginning of man. It is often thought that some time it will reach a maximum, but with bridges such as these constantly being built throughout the world, it seems that progress cannot be halted. Every day, new developments are being introduced and old methods being improved.



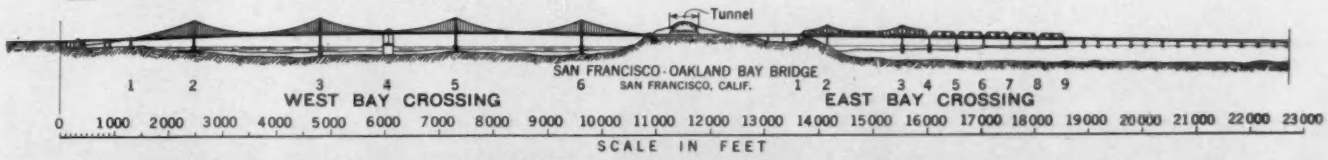
Catwalk and cables in early progress.

CIVIL ENGINEERING

(*Continued from page 15*)

employees or employers. All however living on taxes—with the public tax-conscious as never before. But this is the short time aspect of the situation;—a five-year-look, as it were. It is not a pleasant prospect for men over 50 years of age.

For young men it is a short interval. Their future is ahead of them and America is neither over-built nor well operated. This country has been, is, and yet can be the land of opportunity. It has been profligate, heedless of waste, but straightforward analysis and constructive synthesis can make it a land of far greater abundance. Nor need construction necessarily be only in terms of concrete or steel. It may be in terms of management; management of ideas, things and men. Once, and even yet to too great an extent, water was lugged to the house in pails. Today, however, from faraway hills, or nearby river not too polluted, it can be and is delivered to the city dweller, at all hours of the day or night, here or there, much or little as may be needed, for 4 cents a ton. Cheaper than dirt—far cheaper! Is that not an illustration of what the engineer can and will do to make life more abundant? It is in tune with the times. Produce more, better, cheaper! Create useful facilities! Eliminate waste!



A. M. SIMMONS

The Big Parking Space at Kendall Square

HAVE YOUR CAR SERVICED BY OUR CAPABLE MECHANICS

Expert Servicing, Oil, Gasoline, Lubrication, Tires, and Tubes

BLAST FURNACE

(*Continued from page 7*)

iron it requires about 3½ gross tons of solid materials besides the miscellaneous supplies and repair materials.

The products of the blast furnace are

2240# =	1.00	gross	ton	Pig Iron
1222# =	0.545	"	"	Slag
12721# =	5.679	"	"	Gas
200# =	0.088	"	"	Flue Dust
	7.312	"	"	Total

Roughly speaking this means about 2 tons of ore, 1 ton of coke and half a ton of limestone to make 1 ton of pig iron and a little more than half a ton of slag. This means that a blast furnace plant making 1000 tons of pig iron in 24 hours would require

Inbound	about	2000	tons	of iron ore	= 40	carloads	
"	"	1000	"	" coke	= 25	"	
"	"	500	"	" limestone	= 10	"	
		3500	"		75	"	
Outbound	"	1000	"	" Pig Iron	20		
"	"	550	"	" Slag	11	31	"
To the atmosphere		" 5700	"	Waste Gas	44	"	

The Process

It is a strange metallurgical process that requires 75 carloads of inbound freight, and produces only 31 carloads of outbound freight, sending the equivalent of 44 fifty-ton carloads of waste gases into the atmosphere.

Here again, the mechanical equipment and the mechanical practice have reached such perfection that waste gases are now so thoroughly cleaned that when they are finally wasted into the atmosphere there is less solid pollution than there is in the air in any room.

But the strangest part of the blast furnace process is the immense success in its manufacture in spite of the rather meager knowledge of the fundamentals pertaining to the reduction of iron oxides by means of carbon monoxide in the presence of carbon and carbon dioxide. According to the theories of the scientists and physio-chemists there are reactions of reduction and of re-oxidation continually taking place within the shaft and the bosh of the furnace. From the samples of iron and slag withdrawn through the tuyeres we know positively that these reactions are not complete even when the molten iron and the molten slag pass down through the combustion zones in front of the tuyeres where the solid incandescent coke meets the hot blast, and is converted into a mixture of carbon monoxide and nitrogen having a temperature of about 3500° F.

The molten iron passes down through a layer of molten slag and is instantaneously purified from nearly all the sulphur which had combined with it shortly after being reduced from the oxide. The character of the slag must be such in chemical composition and temperature as to cause the sulphur in the molten iron to be changed into Calcium Sulphide which in turn is dissolved in the molten slag which floats on the surface of the molten iron like cream on top of milk.

Standard Instruments of Precision

C. L. BERGER & SONS
Incorporated
Established 1871
37 Williams Street
BOSTON 19, - MASS.

KELLY SPRINGFIELD TIRES
MENTION OF THIS ADV GOOD FOR SPECIAL DISCOUNT

MARKOW AUTO ELECTRIC CO., Inc.
266 MASS. AVENUE, CAMBRIDGE
Tel. ELIot 8324
BRAKE and ELECTRIC SERVICE
Most Modern Equipped Motor Tune Up and Brake Station In Cambridge
PAY AS YOU RIDE

Philco Batteries
MENTION OF THIS ADV GOOD FOR SPECIAL DISCOUNT

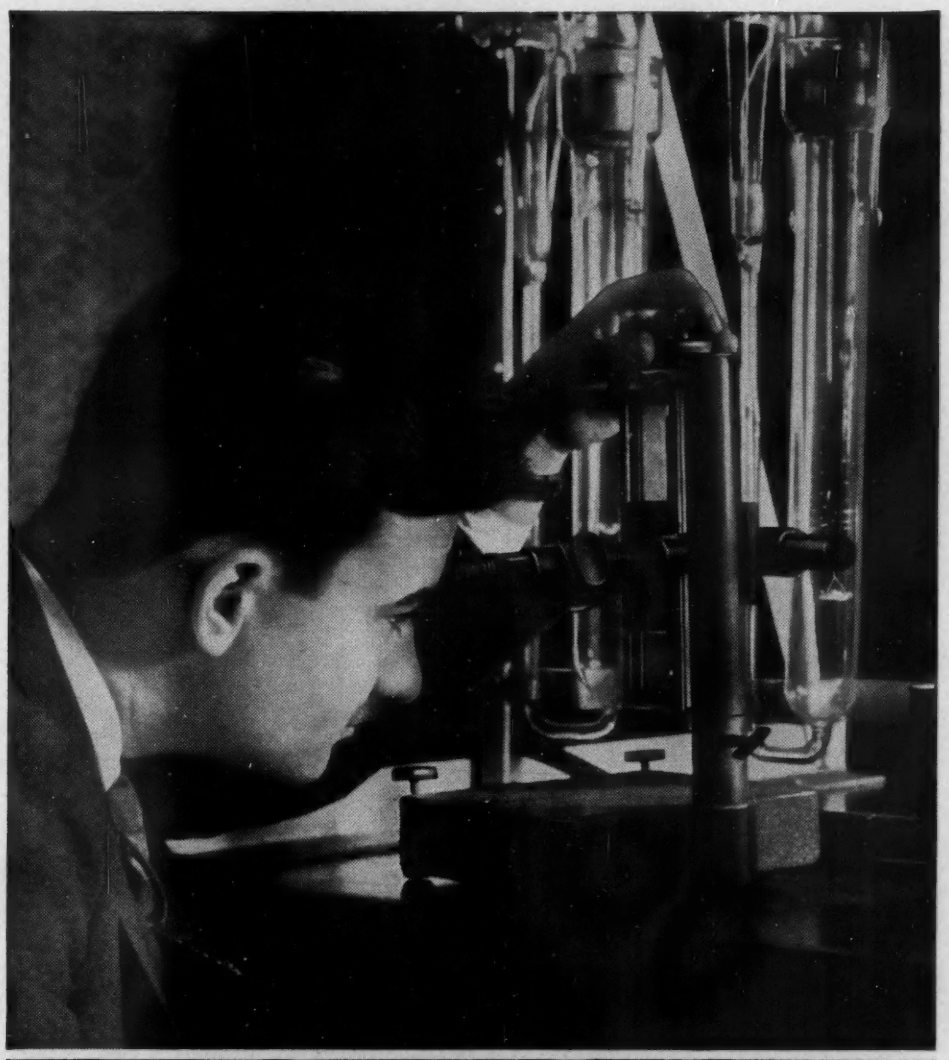
SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish.
The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many specia lcords for special purposes; also cotton twines.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS 89 Broad Street, Boston 9, Mass.



"Assets in the making"

THE work of Bell Telephone Laboratories might well be called "assets in the making." It deals with many problems whose solution will be of great future value to telephone users. ¶ The truth of this statement is indicated by improvements already developed and now in daily use. The convenient handset telephone, the dial system, new magnetic alloys, overseas and ship-to-shore radio telephony are just a few examples. ¶ Today more than 4000 men and women are carrying on this work to make tomorrow's telephone service still better.

Why not telephone home at least once each week? For lowest rates to most points, call station-to-station after 7 P.M. daily, or any time Sunday

BELL TELEPHONE SYSTEM

G-E *Campus News*

LET SCIENCE ARBITRATE

In heated arguments of this kind, the color analyzer is the court of last resort. Recording photoelectric spectrophotometer is the official name of this device, which was recently exhibited at a scientific meeting at St. Louis. It recognizes an infinite variety of hues and shades; it distinguishes differences in color too slight for human eyes to detect; it automatically records the exact color prescription.

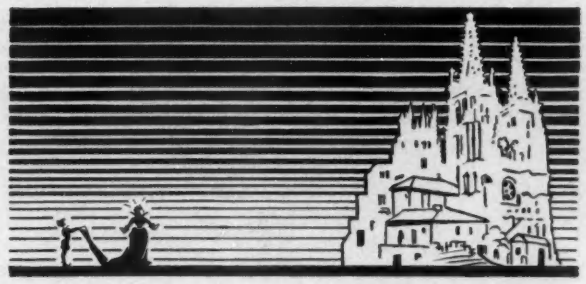
The spectrophotometer is proving especially useful for standardizing the color specifications of inks, dyes, paints, paper, and textiles. It makes obsolete such vague descriptive names as blue-black, blue-white, and yellow-green, and substitutes carefully drawn graphs extending over the whole visible spectrum. The operation of the device, which is automatic, depends upon an ingenious combination of a phototube and thyratron tubes with a precise optical system.

The previous method of making exact color measurements required hundreds of tiresome readings and consumed most of a day. The recording spectrophotometer produces a curve of comparable accuracy in three minutes.

DIG HERE

In the old days, a mysterious individual, called a dowser, with a forked devining rod of witch hazel, used to be called in to locate lost articles buried in the earth. A new magnetic detector, recently developed in the General Engineering Laboratory of the General Electric Company, is now substituting science for magic and hocus-pocus. With uncanny accuracy, it is tracking down lost pipe lines.

Water and gas pipes are often lost because old surveys are inaccurate or because records have been destroyed. Digging up a whole street, in order to find a missing pipe line, is expensive business. The new detector has solved this problem by successfully locating pipes laid 40 years ago—pipes buried as much as seven feet below the surface. In one case, pipes were found fully 100 feet from their supposed location, and the detector spotted them within one diameter of the pipe.



NEW LIGHT ON THE MIDDLE AGES

Medieval ecclesiastics would cry "Witchcraft!" could they see the cathedral at Burgos, Spain, tonight. Carefully wrought details of architecture and ornamental carving, never before clearly seen in all their seven hundred years, now stand forth in bold relief. The thirteenth-century Gothic structure glows, for two hours each night, in the light of a battery of modern General Electric floodlights.

Burgos was, for centuries, the capital of Old Castile, the kingdom of that Queen Isabella who offered to pawn her jewels to finance Columbus' momentous voyage to America. Now, after 444 years, American lighting equipment returns to add luster to what was one of the most important of Isabella's possessions.

96-237DH

GENERAL ELECTRIC

The Kendall Printing Company